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Administration

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FY 2010 Accomplishments

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INTRODUCTION

The *R&D Annual Review* highlights the 2010 research and development (R&D) accomplishments of the Federal Aviation Administration (FAA), and serves as a compendium to the FAA's *National Aviation Research Plan* (NARP), 2011 edition. The FAA's R&D portfolio assists in achieving the 10 R&D goals described in Chapter 2 of the NARP. This publication represents the accomplishments aligned with the supported R&D goals: Fast, Flexible and Efficient; Clean and Quiet; High Quality Teams and Individuals; Human-Centered Design; Human Protection; Safe Aerospace Vehicles; Separation Assurance; Situational Awareness; System Knowledge; and World Leadership.

Additionally, the R&D portfolio supports the FAA's core goals to enhance safety, improve efficiency, and increase capacity of the national airspace system or NAS. In that effort, it continues to lay the groundwork for the Next Generation Air Transportation System known as NextGen.

NextGen is a wide-ranging transformation of the entire NAS to meet future demand and support the economic viability of the system while reducing delays, improving safety, and protecting the environment. It is a complex, multilayered, evolutionary process of developing and implementing new technologies and procedures. NextGen is not a single piece of equipment or a program or a system that will instantaneously transform the NAS. It is an evolutionary process, and existing systems must be sustained in the transition. NextGen builds on legacy systems to increase capability in today's airspace system, adds new performance-based procedures and routes, and ultimately delivers programs that will transform the NAS.

How the FAA will achieve that NextGen transformation is detailed in some of the R&D accomplishments found in this issue.

Today, capacity for Closely Spaced Parallel Runway Operations (CSPO) is dramatically reduced in poor visibility conditions. The R&D portfolio is working on capabilities that allow for continued use of runways during low visibility by providing precise path assignments that permit safe separation between aircraft assigned on parallel paths, restoring capacity, and reducing delays throughout the system.

Increased efficiency with NextGen operations will lead to reduced fuel consumption resulting in lower carbon emissions. The agency's R&D effort is researching engine and airframe design and alternative fuels that will produce the changes needed to reduce aviation's environmental impact.

These accomplishments begin to tell the NextGen story and provide a glimpse into the future of our nation's world class aviation system and the immense benefits it will continue to provide to the American people.

FAST, FLEXIBLE, AND EFFICIENT

A system that safely and quickly moves anyone and anything, anywhere, anytime on schedules that meet customer needs.

A COMPREHENSIVE GUIDEBOOK FOR PLANNING AND IMPLEMENTING AUTOMATED PEOPLE MOVER (APM) SYSTEMS AT AIRPORTS

The guidebook includes a CD-ROM with interactive tools designed to assist airports to plan and implement an APM system. The scope of this research includes APM systems that provide transportation on airport grounds as well as access to remote facilities (e.g., airport parking, car rental facilities, hotels, off-airport public transportation, and other related activity centers). (ACRP)

IMPROVED AVIATION SYSTEM CAPACITY

Integrated strategic actions were developed to enhance decision making to address the constrained aviation system capacity and growing travel demand in the high-density, multijurisdictional, multimodal, coastal mega-regions along the east and west coasts. The research results will be used by transportation agencies and operators, as well as for informing public officials at the federal, state, and local levels. (ACRP)

IMPACTS OF CONSTRAINED AIRPORT PARKING

A handbook was developed for airport operators to use to assess the access impacts of constrained public and/or employee parking at airports. For airports where constrained parking exists or is expected, the handbook provides guidance on how to quantify the impacts of potential changes in airport customer and employee access resulting from strategies such as changes in parking rates, the provision of new or improved public or private transportation services, and the introduction of remote parking facilities. The handbook allows airport operators to better understand, anticipate, and evaluate changes in airport parking strategies at airports where constrained parking exists or is expected. (ACRP)

AIRPORT SYSTEM PLANNING PRACTICES

The state of airport system planning practices gathered through a review of literature and a survey of state aviation agencies, regional planning organizations, and the FAA was documented. The primary audience for this synthesis report includes airport operators, regional planning agencies, state aviation agencies, and the national and regional FAA staff. (ACRP)

APRIL 2010 BOEING 757 AIRCRAFT WAKE SEPARATION STANDARDS UNIFIED BY FAA REGULATIONS

Prior to April 8th, FAA controllers and supporting automation systems had to apply differing wake separations to Boeing 757 aircraft depending on aircraft series (200 or 300 series). The varying standards were put in place prior to the more recent advances in the use of Light Detection and Ranging (LIDAR) systems to track and characterize aircraft generated wakes. The varying standards were causing problems with international flight plans, which did not distinguish between the two 757 aircraft series and were an added complexity for controllers separating aircraft for wake mitigation. A study completed in Fiscal Year (FY) 2010 using LIDAR wake tracking data and earlier wake track data bases, found that the wakes of the 200 and 300 series aircraft were nearly identical in their characteristics/ transport and that only a single 757 set of wake separation standards was required. The study's recommendation was adopted and implemented by FAA Order 7110.520 and Order 7110.525, both effective April 8, 2010. (NextGen-Wake Turbulence)



AIR TRAFFIC CONTROL DEPENDENT STAGGER INSTRUMENT APPROACH PROCEDURE FOR NON-VISUAL AIRPORT OPERATIONS

Newark and Memphis Airports' closely spaced parallel runways (CSPR) have been assessed and approved for use of this new operation. Currently when weather conditions dictate the use of instrument approach landing operations, the number of landings the Newark and Memphis CSPR can handle is cut roughly in half. Approval of the use of the Dependent Stagger Instrument Approach procedure for Newark's 4L/4R and 22R/22L CSPR; and, Memphis' 18C/18L and 36R/36C CSPR will allow an increase of up to eight to ten more landings on the runway pairs per hour during non-visual operations. The implementing FAA Order 7110.308 Change 2 became effective September 1, 2010. (NextGen-Wake Re-categorization)

AVOIDING ICING CONDITIONS IN ALASKA

National Transportation Safety Board (NTSB) data indicates that in-flight icing causes more than 25 accidents annually, with more than half resulting in fatalities and destroyed aircraft. This equates to \$100 million in injuries, fatalities, and aircraft damage each year. To address this problem, FAA researchers developed the Current and Forecast Icing Products (CIP and FIP) which provide more accurate and timely diagnoses and forecasts atmospheric conditions leading to ice accretion on aircraft during flight. CIP and FIP (depicted graphically, via the Aviation Digital Data Service (a web-based dissemination system operated by the Aviation Weather Center)) provide the probability that icing will occur along the planned route of flight as well as its expected severity.

As in-flight icing is a major aviation hazard in Alaska, researchers are developing CIP and FIP products for Alaska. In FY2010, the Alaskan version of CIP was approved to begin the test phase.

In-flight icing is a potential hazard to all classes of aircraft including those with ice protection. The formation of even a thin coat of ice on an aircraft surface can seriously impact its ability to fly by increasing drag, decreasing lift, and adversely affecting controllability. At greatest risk are aircraft without ice protection and those that fly at relatively low altitudes where they are more likely to encounter atmospheric conditions conducive to icing. FAA researchers have already developed CIP and FIP for the continental US. (Weather Program)

ENHANCING WEATHER MODELS

In-flight icing, turbulence, convective weather, and low ceilings and visibility affect both the capacity and safety of the NAS on a daily basis. Timely and precise forecasts of these aviation-specific weather hazards require forecast models that are not only accurate and updated frequently, but that can be easily enhanced as research advancements become available. The Weather Research and Forecasting (WRF) Model, completed in FY 2010, is an operational next-generation numerical weather prediction system designed to serve both operational aviation forecasting and atmospheric research needs. WRF Model outputs are key to reducing weather delays and thus achieving the FAA Flight Plan's greater capacity goal as well as NextGen weather operational improvements. Development of the WRF Model was done in collaboration with the FAA, the National Oceanic and Atmospheric Administration (NOAA), the Air Force Weather Agency, the US Naval Research Laboratory, the University of Oklahoma, and the National Center for Atmospheric Research.

The WRF model, with a one-hour update rate, was transitioned to NOAA's National Centers for Environmental Prediction for operational implementation. Also known as the WRF-Rapid Refresh (RR), this version of the WRF Model provides 13km resolution, short-range weather model forecasts out to 18 hours as well as one-hour background forecasts for a high frequency 3-D objective analysis across North America. The WRF-RR data will be used as input for FAA-developed aviation weather applications that produce weather hazard forecasts. (Weather Program)

4-DIMENSIONAL (4D) FLIGHT MANAGEMENT SYSTEM (FMS) TRAJECTORY-BASED OPERATIONS (TBO)

Center for Advanced Aviation System Development (CAASD) researchers are key contributors to the FAA 4D FMS TBO research program. 4D TBO leverages existing technology and FMS capabilities as a starting point for informing standards and requirements for trajectory exchange, time of arrival controls, and other building blocks needed to meet both the desired mid-term operations described in the NAS Enterprise Architecture (EA) and far-term operations described in the Joint Planning and Development Office (JPDO) NextGen Concept of Operations (CONOPS).

In 2010, various activities were completed including analysis of operational data, Human-in-the-Loop Simulations (HITLS) and flight trials. During these activities CAASD provided the tools to conduct the HITLS, scenarios, parametric studies of FMS Required Time of Arrival (RTA) behavior, and Air Traffic Control (ATC) operational analysis to ensure the viability of the flight trials. Results from these activities were analyzed by CAASD as they relate to validating current standards and developing future RTA standards.

To support the data analyses in 2010, CAASD has implemented a data-feed to receive real-time FMS intent downlink data from two airline partners. The primary content of the intent data is the aircraft estimated time of arrival for future waypoints as well as for Top of Climb and Top of Descent. Intent data from close to 100,000 operational flights were analyzed to provide a characterization of FMS intent in the current operational environment in which ATC and pilot interventions frequently invalidate FMS trajectory predictions. CAASD has also gained access to operational Traffic Management Advisor (TMA) data for numerous facilities to support the ongoing research. CAASD analyzed several months of TMA data from Houston Air Route Traffic Control Center to characterize meter-fix delivery accuracy in the current environment. CAASD also analyzed TMA data from Seattle Air Route Traffic Control Center (ARTCC) from the period of the flight trials to compare TMA trajectory predictions to FMS trajectory predictions.

To support the June 2010 HITLS, CAASD provided a portable simulation capability which was installed and used at the Embry Riddle Aeronautical University NextGen test-bed facility to validate a concept for using FMS RTA capabilities to meet meter-fix times. CAASD provided the simulation capability, helped run the HITLS and provided a quick-look report to support a go/no go decision for October flight trials.

To support the October 2010 flight trials, CAASD performed parametric sensitivity analysis using General Electric (GE) Aviation FMS simulators to characterize FMS RTA behavior. The RTA was given to a selected set of Alaska Airlines B737NG aircraft based upon scheduled times of arrival from TMA. CAASD also provided inputs into the trials plan, safety analysis, and operational analysis; and was on site for the week long trials period supporting data collection and understanding operational issues. To facilitate data collection, CAASD also installed a data-feed to collect FMS downlink data and setup web-based data collection forms for pilot and controller feedback. Development of the content of the feedback forms was led by CAASD with input from other project stakeholders. CAASD also worked with GE Aviation and MIT Lincoln Lab to generate a quick-look report and a detailed flight trials report. (CAASD)



TERMINAL ATC CAPABILITIES FOR EFFICIENT HIGH DENSITY OPERATIONS

The FAA has a critical need for improving efficiency and throughput in high density terminal operations. RTCA Task Force 5 recommendations called for an increase in capacity and throughput for converging and intersecting runway operations. Additionally the NextGen Segment Implementation Plan contained an OI for Increase Capacity and Efficiency using Area Navigation (RNAV) and Required Navigation Performance (RNP).

In response to these recommendations, the FAA committed to demonstrating the CAASD-developed Relative Position Indicator (RPI), future automation designed to aid air traffic controllers in merging and spacing on terminal RNAV and RNP routes, at two terminal sites in 2010 to support future NextGen capabilities. CAASD assisted the FAA in planning and conducting these Terminal Radar Approach Control (TRACON) field evaluations of the RPI capability at Southern California TRACON for operations at San Diego International Airport and Phoenix TRACON for operations at Phoenix/Sky Harbor International Airport. The field evaluations consisted of a demonstrator system of the RPI prototype on the operational floor connected to a live data feed as well as HITL simulations based off of historic traffic. The purpose of the field evaluations was to expose controllers to the RPI prototype to demonstrate how RPI can assist their efforts in merging arrival flows.

Operational insight and feedback from facilities regarding the functionality, acceptability, and benefits of RPI use to manage merging arrivals were recorded. Controller questionnaires at both facilities indicated an increase in situational awareness, increase in the predictability of traffic, and a reduction in workload. The full quantitative analysis of the field evaluations will be provided in FY 2011. (CAASD)

SURFACE TRAJECTORY-BASED OPERATIONS TOWER RESEARCH

The FAA is developing a concept for surface operations in the NextGen called Surface Trajectory-Based Operations (STBO). STBO introduces new automation and procedures to improve decision-making, efficiency, and safety regarding airport configuration changes, scheduling and sequencing aircraft for departure, assigning runways and taxi routes, and monitoring conformance on the surface. In FY 2010, CAASD researchers developed concepts of use for STBO decision support tools and began validating and refining the concepts through HITL simulations in CAASD's Aviation Integration Demonstration and Experimentation for Aeronautics Laboratory (IDEA Lab).

One of the mid-term features of STBO, monitoring conformance to taxi routes, is a key research area for CAASD and CAASD's research partners. For example, CAASD and Mosaic ATM are partnering to evaluate aspects of the surface conformance monitoring concept using prototype decision support tools. In FY 2010, two HITL simulations were designed and conducted by CAASD researchers in CAASD's IDEA Lab to assess the feasibility and benefits of the surface conformance monitoring concept. In the concept of operations for this monitoring capability, automation provides the tower controller with suggested taxi routes for departing flights, and then monitors conformance to the assigned taxi routes – alerting the controller when problems arise.

CAASD developed and used a high-fidelity, HITL tower simulation platform for this effort, and a major milestone for this work was integrating Mosaic ATM's Surface Decision Support System into this platform for demonstration and simulation purposes.

For each HITL simulation conducted, CAASD enlisted certified professional controllers currently or previously working at FAA control towers to serve as participants in the study. The participants were responsible for assigning taxi routes and monitoring pilot conformance to these routes, both in a manual environment and using the STBO toolset. Results were positive and indicate potential benefits of STBO. The results indicated an increase in the number of deviation detections as well as a decrease in detection times in some cases. The participants' workload was reportedly reduced while using the STBO toolset as well. Participants reported favorably on the design and use of the non-conformance altering capabilities. Additional research areas, such as concept and prototype refinement, were identified and will be investigated through HITL simulation at CAASD in FY 2011 and FY 2012. (CAASD)

HIGH DENSITY AREA DEPARTURE/ARRIVAL MANAGEMENT (HDDAM)

The NAS is a complex dynamic system that can exhibit unpredictable behavior during disruptive events such as severe weather. In order to enable safe and efficient flow of aircraft in NextGen, it is critical to ensure stable operations in the presence of disruptive weather events. Arrivals and departures in high density terminal areas are particularly sensitive to such disruptions. A contributing factor to this instability is the fact that the point of action (the airport tower) is far removed from the point of traffic flow decision making ARTCC.

In FY 2010, CAASD researchers developed the HDDAM concept, identified roles and responsibilities for high density area departure traffic management, developed lab experiments to validate the HDDAM departure CONOPS, developed a prototype to support planned lab experiments, and developed a TRACON slot allocation algorithm for the first HDDAM lab experiment within the MITRE IDEA Lab. The initial analysis and assessment of the performance and suitability of the concept, has been completed and initial results indicate that over 85 percent of the participants view the concept positively and believe that this would contribute to more efficient facility operations. (CAASD)



Air Traffic Controllers at Potomac Consolidated TRACON

CLEAN AND QUIET

A reduction of significant
aerospace environmental
impacts in absolute terms

AVIATION NOISE RESEARCH FRAMEWORK

Noise impacts continue to be a major aviation environmental concern despite a 90 percent reduction since 1975 in the number of people in the US exposed to significant aircraft noise. The persistence of significant levels of aircraft noise in communities around airports is a major impact, but not the only one. There are increasing concerns in areas of moderate noise exposure and public complaints from suburban and rural areas where ambient noise is lower. At noise exposure levels below those involving health and welfare concerns, there are also sensitivities with respect to national resources such as National Parks.

With input from domestic and international stakeholders, the FAA is developing a systematic Aviation Noise Research Framework to improve the scientific knowledge base of the extent of aviation noise impacts and develop appropriate mitigation below historically-defined significant noise levels. The research framework, while covering a broad set of aviation noise topics, focuses on the following critical research areas: (1) quantification of potential noise impact on health and welfare in noise compatible areas; (2) systematic review of the basis for the current practice of characterizing airport communities' noise impact in terms of Day-Night Average Sound Level (DNL)*; (3) analysis of noise impacts on national park and wilderness areas; (4) characterization of noise propagation in all regimes of aircraft operations and their impacts on the surface; (5) development of acceptability standards and noise impacts of supersonic and future unconventional aircraft; and (6) definition of the social cost of aircraft noise impacts relative to other aviation environmental impacts.

To develop the noise research framework, FAA convened an international forum in Ottawa in 2009, and two public workshops in Washington, DC, in 2009, and San Diego, CA, in 2010, to focus on aircraft noise effects on sleep disturbance and annoyance. These discussions identified research activities to address aviation's global capability and knowledge gaps, some of which have since started. Together with noise-related studies conducted by the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER)[†] through the Airport Cooperative Research Program (ACRP)[‡] and the US Department of Transportation (DOT) Volpe Center, under the FAA Air Tour Management Plan, the FAA's more recently-initiated research activities form a complement of work that seeks to advance scientific knowledge to better address the impacts of aviation noise on society. (Environment and Energy)

* The DNL is a standard Federal metric for quantifying cumulative exposure of individuals to noise. DNL was initially developed and used by the Environmental Protection Agency (EPA).

[†] An FAA Center of Excellence (COE) sponsored by the FAA, Transport Canada, and the National Aeronautics and Space Administration (NASA).

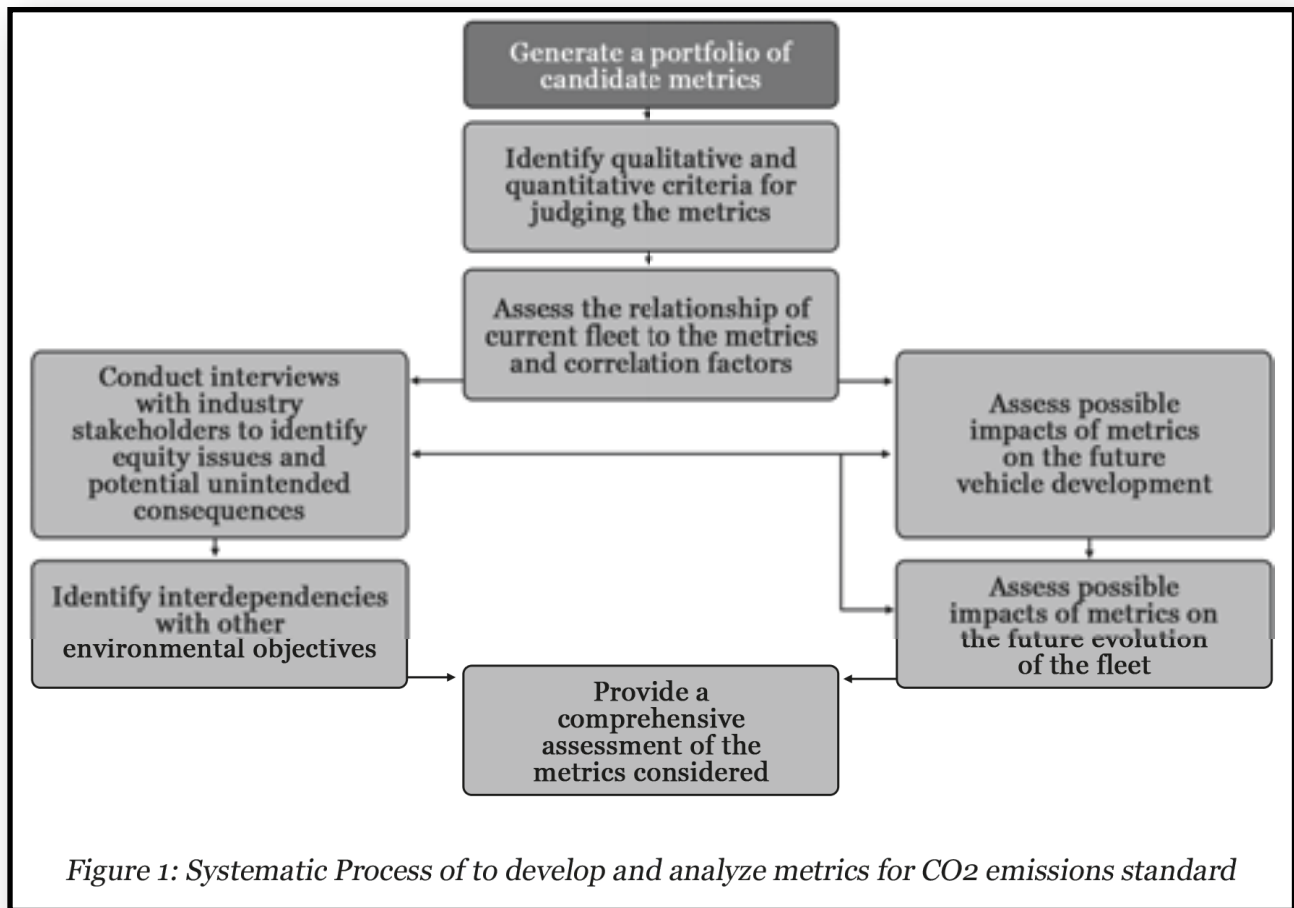
[‡] The ACRP is sponsored by the FAA and managed by the National Academies, through the Transportation Research Board, in coordination with Airports Council International-North America, Airport Consultants Council, American Association of Airport Executives, National Association of State Aviation Officials, and Air Transport Association of America.

ESTABLISHING AIRCRAFT CO₂ EMISSIONS STANDARD

Growing concerns over climate change create an impetus for reducing greenhouse gas (GHG) emissions from all sectors of the global economy. Despite the substantial historical reductions of fuel burn and pollutant emissions from commercial aviation, it is expected that further improvements will be required, especially if the global long-term demand for air transportation continues to grow and neutral or reductions of net GHG emissions are targeted. There are many compounds that fall under the category of a GHG, but carbon dioxide (CO₂) has received much attention for its prevalence. From a policy standpoint, there are several mechanisms to further incentivize the reductions of CO₂ emissions, including establishment of an aircraft certification standard. Due to the international nature of aircraft design and manufacture, and airline operations, the development of a CO₂ emissions standard is being conducted under the auspices of the International Civil Aviation Organization's Committee on Aviation Environmental Protection (CAEP). The current CAEP work program calls for the standard to be established by the end of 2013, and the FAA is participating in the activity to build its technical basis.

To address this work, the Office of Environment and Energy (AEE) is conducting a study to inform the development of a CO₂ standard. A standard (or certification requirement) is composed of three elements; (1) a metric, (2) a scope of applicability and (3) a certified level. The study objective is to identify robust metrics that objectively and accurately reflect CO₂ emissions at the aircraft and fleet levels, and the purpose is to inform national and international processes by (1) identifying metrics that could be used as a basis for the aircraft certification requirement, (2) evaluating the advantages and disadvantages of each metric and (3) providing comprehensive assessments of metrics and related analyses. The study is being conducted under PARTNER. Specifically, Massachusetts Institute of Technology (MIT) and Georgia Institute of Technology are performing this work under a PARTNER project entitled Assessment of CO₂ Emission Metrics for Commercial Aviation Certification and Fleet Performance Monitoring.

In this project, a multi-pronged approach was begun to investigate the assessment of CO₂ emission metrics for commercial aircraft certification and fleet performance monitoring, as shown in Figure 1. First, a portfolio of candidate metrics was generated through brainstorming sessions, literature review and interviews with stakeholders. In order to evaluate metrics, a set of qualitative and quantitative criteria were developed. Subsequently, an assessment of the relationship of the current fleet performance to the metrics and correlation factors was initiated. In two parallel tracks, the project then focused on assessing the possible impacts of the metrics (and potential certification standard) on both the future development of aircraft and the evolution of the fleet. Also in parallel, interviews with stakeholders are being conducted in order to identify any equity issues and potential unintended consequences. Interdependencies with other environmental objectives (e.g. noise and other gaseous emissions standards) are to be evaluated. Finally, the results of the evaluation of the metrics from each of the evaluation phases are being synthesized into a comprehensive assessment of candidate metrics.



From first principles, as shown in Figure 2, the study identified that total fleet-wide CO2 emissions from commercial aviation are a function of 3 key parameters:

1. Fuel CO2 content: i.e., emissions generated by the use of one unit of energy of fuels or a blend of fuels,
2. Aircraft fuel energy intensity: i.e., energy required to generate one unit of output of air transportation services, and
3. Operational factors: i.e., Airline Business Constraints and Operational Inefficiencies. These operational factors are composed of (a) a generic load factor measure, (b) inefficiency of air traffic control system and (c) business constraints & operational inefficiency of airline. The product of these factors is summed over the total actual air transportation output.

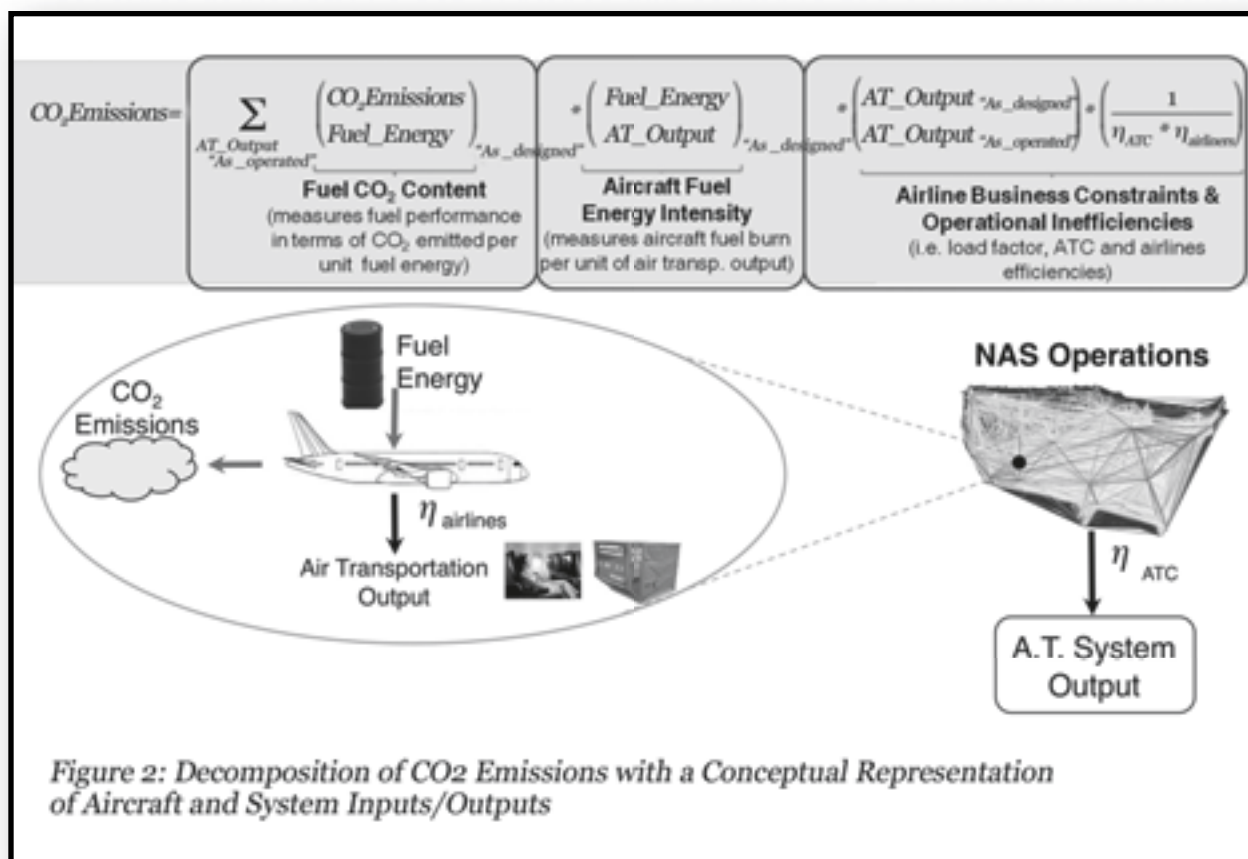


Figure 2: Decomposition of CO₂ Emissions with a Conceptual Representation of Aircraft and System Inputs/Outputs

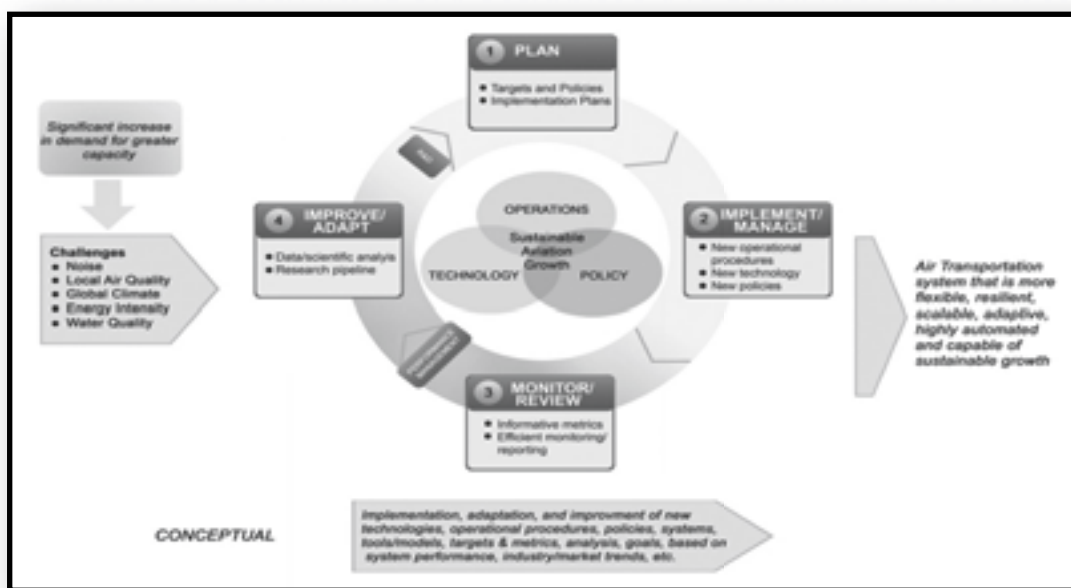
The objective of identifying aircraft certification metrics therefore focuses on the central parameter (i.e., aircraft fuel intensity). This was defined as the ratio of Fuel Burn to Air Transportation Output, where air transportation output can be constructed as the product of a combination of three categories of parameters; (1) measure of distance, (2) measure (or a proxy) of what is transported and (3) a measure of speed. The systematic generation of candidate metrics resulted in a large set of metrics combining all three measures. However, based on preliminary analyses, the in-depth analyses will focus only on the most promising metrics. As an example, some of these include (1) specific air range, i.e. a well-known instantaneous measure of aircraft fuel efficiency that is analogous to ‘miles-per-gallon’ for automobiles and represents the incremental air distance an aircraft can travel for a unit amount of fuel at a particular flight condition, and (2) block fuel (i.e. full flight fuel burn) divided by combinations of favorable aircraft parameters such as maximum take-off weight, payload, range, cabin floor area, and/or number of available seats.

These results are based on preliminary analyses that will be refined in the remaining phase of the project. Continuing and future work will proceed along a variety of fronts that will help expand the breadth of information available to draw conclusions about the benefits and drawbacks of the various CO₂ metrics. All work will be combined into a comprehensive evaluation of the most promising metrics. (Environment and Energy)

NEXTGEN ENVIRONMENTAL MANAGEMENT SYSTEMS (EMS)

The NextGen goal to increase NAS mobility and efficiency is dependent upon the ability to adequately address and mitigate aviation environmental impacts and to deal with related energy issues. The primary environmental and energy issues that significantly influence the capacity and flexibility of the national airspace system are aircraft noise, air quality, climate, energy, and water quality. The AEE is leading the development of a strategic EMS approach for integrating environmental and energy objectives into the planning, decision-making, and operation of NextGen. EMS is a management framework by which an organization identifies environmental aspects and impacts of its operations, assesses current performance, and formulates targets and plans to achieve improvements.

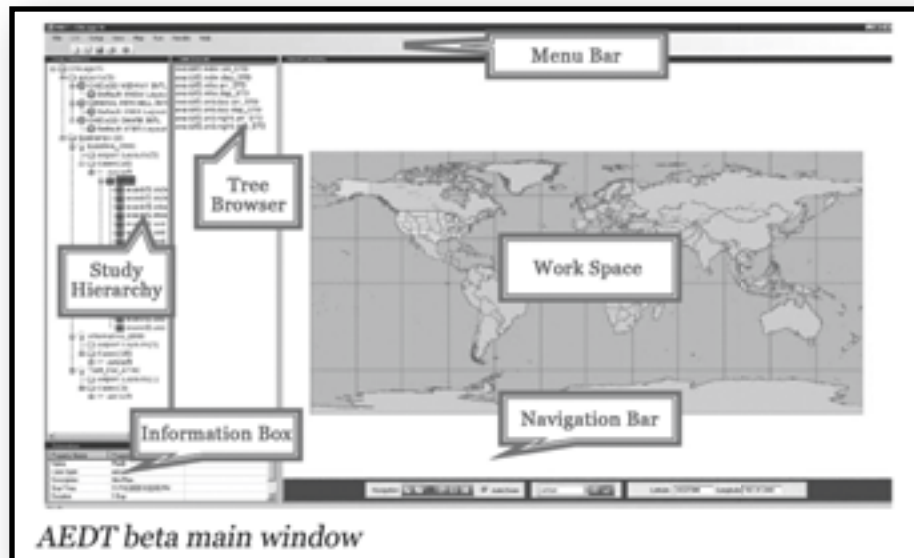
The NextGen EMS framework is based on industry standard EMS principles. At a high level there are four phases, including plan, implement/manage, monitor/review, and improve/adapt. In the plan phase, significant environmental issues are identified and evaluated, and goals and plans to manage these issues are developed. In the implement/manage phase, plans are implemented to manage significant environmental issues (i.e., reduce or avoid negative impacts or maximize positive impacts). During the monitor/review phase, the effectiveness of these implementation activities is monitored and key performance metrics are tracked. This data is then used during the improve/adapt phase to make improvements and course corrections. .



NextGen EMS focuses on addressing the environmental constraints to sustainable aviation growth and efficiency, recognizing that these constraints might change over time. The strategic nature of the NextGen EMS will drive the air transportation system toward the achievement of long-term goals through the establishment of management system elements at both the enterprise and organizational levels. It will also provide improved data and information flow that will allow better decision-making in a timelier manner. In turn, this will enable technology, operational procedures, and policy to be refined and adapted to meet real operating conditions in a cost effective manner. (Environment and Energy)

AVIATION ENVIRONMENTAL DESIGN TOOL

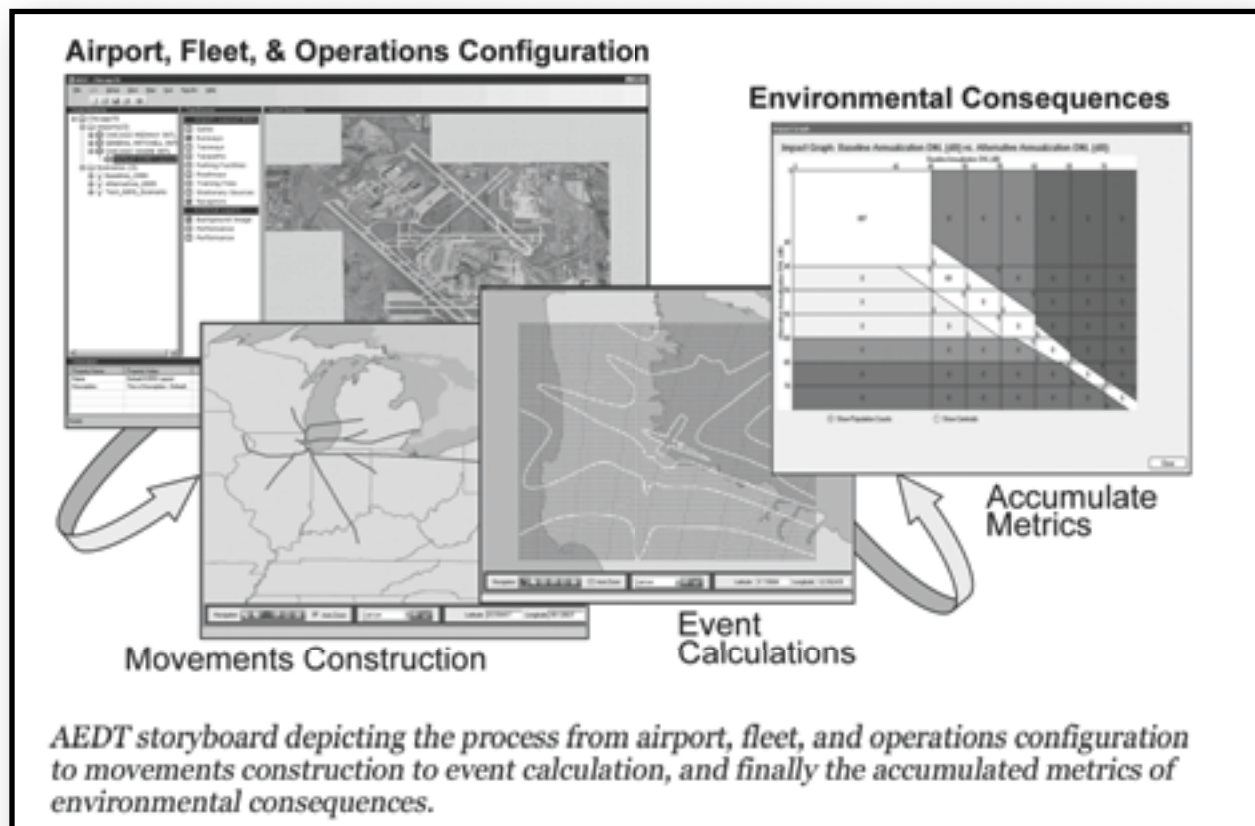
The FAA achieved several major milestones toward an integrated aviation environmental modeling capability that accurately quantifies the interdependencies of aircraft fuel burn, noise, and emissions in 2010. The focus of the Aviation Environmental Design Tool (AEDT) development this year was to establish regional modeling capabilities that represent the environmental review capabilities of airspace redesign projects, with the goal of ultimately replacing the legacy functionality of the Noise Integrated Routing System in 2011. Three AEDT beta versions were produced sequentially, each with increasing functionality that evaluated the regional environmental aspects of commercial aviation. The beta software was released to AEDT Design Review Group (DRG) members as a Windows™ application that uses state-of-the-art software technology such as Standard Query Language relational databases and Geographical Information System functionality. The membership of the AEDT DRG is comprised of multiple US government agencies, contractors, industry, and international modeling stakeholders who voluntarily test AEDT beta versions and provide feedback on model development issues related to usability, functionality, and data management.



The 2010 beta versions of AEDT demonstrated the capability to ‘fly’ aircraft in three dimensional space and time across regions that contain multiple airports. High fidelity weather files were incorporated to more accurately determine the location of the aircraft in each phase of flight and calculate improved fuel consumption – a new modeling capability. Within AEDT, the ability to investigate changes in fuel burn, noise, and emissions between a baseline and alternative scenarios was also incorporated. Another new functionality, mitigation, was created to manipulate operations to reduce hot spots of noise and/or emissions. The ability to model helicopters was also added for use in regional studies. The beta tool was tested to produce a variety of reports and graphical displays of receptor grids, noise contours, and population centroids. In addition, highly sophisticated programming enabled multiple computers networked together to share in the computational tasks, thereby shortening run time for large, data-intensive studies. Finally, the AEDT standard input file created the efficient ability to import large datasets into AEDT without the use of clicking through multiple graphical interface screens.

Interdependent environmental capabilities are critical to the JPDO vision for NextGen as well as NASA's research towards analyzing advanced vehicle concepts in NextGen scenarios. Environmental modeling in support of JPDO's Interagency Portfolio & Systems Analysis division began using the AEDT beta versions to analyze the environmental consequences of future NextGen scenarios produced by NASA's Airspace Conflict Evaluation Simulator tool.

In addition to becoming the FAA's official tool for compliance with the National Environmental Policy Act and other environmental regulations, AEDT will be the primary evaluation tool for the NextGen EMS. It will provide the necessary strategic and systematic evaluation capabilities to identify and manage aviation-related environmental issues. The robust functionality of AEDT will help to ensure that the environmental benefits of NextGen are maximized, while constraints are identified and redacted or avoided. These capabilities will inform decision makers in a variety of settings such as establishing operational programs in air traffic management (ATM), determining national/international policies, quantifying the benefits of cleaner and quieter technologies, strategic planning forums, and planning service and facility provider options. (Environment and Energy)



SUSTAINABLE ALTERNATIVE AVIATION FUEL

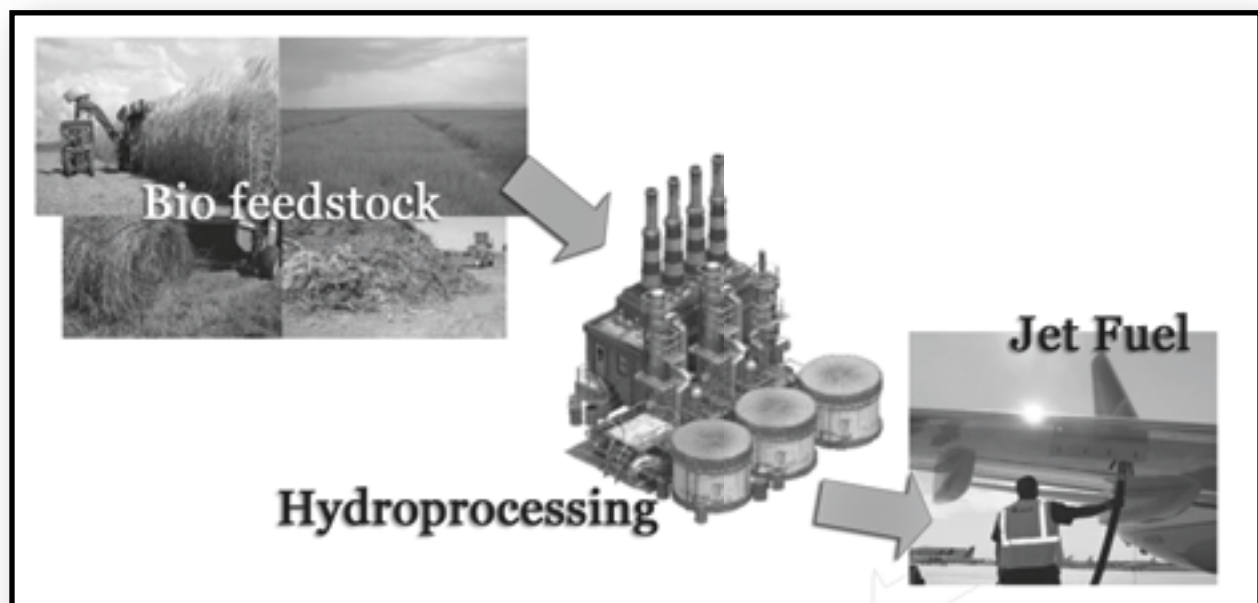
The FAA is addressing barriers and enabling end use of sustainable alternative fuel in commercial jet aircraft through efforts by the PARTNER COE, the Commercial Aviation Alternative Fuels Initiative (CAAFI), and the Transportation Research Board's ACRP. FAA is leveraging overall federal efforts and continues to work in close partnership with the Department of Defense, NASA, Department of Energy (DOE), EPA, and Department of Agriculture to meet research and development goals and achieve consensus on environmental and fuel standards and deployment needed to support sustainable alternative fuels for jet aircraft.

New Fuel Approvals Anticipated

CAAFI is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants, and US government agencies. It continues to play a key leadership role in facilitating the approval of additional sustainable alternative fuels to last year's established specification for synthetic aviation fuel (American Society for Testing and Materials (ASTM) D7566). This year CAAFI is facilitating fuel qualification and certification of hydroprocessed renewable jet fuel, a plant-oil based biofuel, required before it can be added to ASTM D7566 and approved for commercial aviation use.

Environmental Analysis

Harnessing the benefits of alternative jet fuels depends on our ability to understand the full life-cycle costs and impacts of fuel production and use on GHG, food supply, and water sustainability. The PARTNER COE conducts a number of projects to analyze the environmental impacts, costs and benefits of sustainable alternative fuels for aviation. This year, progress includes GHG lifecycle analyses for 16 alternative jet fuel pathways; alternative fuel combustion emissions measurements to determine air quality benefits; and development of a framework and guidelines for life cycle analysis in conjunction with the US Air Force, EPA and DOE. (Environment and Energy)



NO_x EMISSIONS SCIENCE AND IMPACTS IN THE CONTEXT OF STRINGENCY

The influences of aircraft landing and takeoff cycle (LTO) nitrogen oxide (NO_x) emissions upon surface ozone concentrations are fairly well-known and this knowledge has been used as the primary basis for historical decisions regarding the stringency of the NO_x emissions standard for aircraft engines. However, the way that aircraft LTO NO_x emissions change ambient particulate matter (PM) concentrations can have a much more negative environmental impact than the way that aircraft LTO NO_x emissions change ambient ozone concentrations. Thus, aircraft NO_x emissions control must be considered in the context of NO_x impacts upon concentrations of ambient PM.

In FY 2010, research was performed in several areas through the PARTNER COE. An Airport Surface Movement Optimization project is investigating the reduction of emissions through improved aircraft departure planning and surface traffic movement by developing an algorithm to optimize departure queue management. During FY 2010, the algorithm was successfully tested in collaboration with airlines at Boston Logan Airport.

A project on En Route Traffic Optimization is developing a prototype algorithm to be used in an optimization tool that investigates and quantifies both economic and environmental benefits by assigning aircraft an optimum cruise altitude, heading and speed. In FY 2010, the algorithm was refined for testing in FY 2011 at the FAA Technical Center with air traffic controllers. A third PARTNER COE project identified and systematically evaluated a set of potential near-term operational mitigations across all phases of flight, against a common set of environmental impact and feasibility criteria. This makes it possible to determine the relative potential of the various mitigation options.

In addition to research projects, the FAA's international collaboration includes two initiatives. The Atlantic Interoperability Initiative to Reduce Emissions is an international partnership established by the FAA and the European Commission. Through this partnership FAA and the European Commission seek enhanced ATM interoperability, improved energy efficiency, reduced engine emissions, and lower aircraft noise through accelerated development and implementation of environmentally friendly procedures for all phases of flight, from gate to gate. In FY2010, demonstration flights were conducted using NextGen procedures that allowed the aircraft to fly more efficient routes, saving time and fuel burn. Similarly, the Asia & Pacific Initiative to Reduce Emissions (ASPIRE) is a partnership of air navigation service providers (ANSPs) dedicated to reducing emissions and increasing efficiency by identifying underutilized deployment-ready procedures and shepherding them into industry-wide adoption. ASPIRE was formed in 2008 and consists of Airservices Australia, Airways New Zealand, the Japan Civil Aviation Bureau, the Civil Aviation Authority of Singapore. In FY2010, gate-to-gate demonstration flights were conducted using operational procedures that reduce fuel and emissions.

AEE will continue to advocate the importance of our operations research efforts to ensure critical mobility-related energy and environmental challenges are overcome through NextGen. (Environment and Energy)

HIGH QUALITY TEAMS AND INDIVIDUALS

The best qualified
and trained workforce
in the world

DATACom REDUCES DEFINED ANTICIPATED CONTROLLER WORKLOAD

In 2010, researchers completed initial investigations into application of DataCom in the TRACON domain. Researchers introduced DataCom to the workstation as a total package that may represent the 2018 environment. It included RNAV routes and arrival procedures in the terminal area and decision support tools that may be representative of NextGen improvements in mid-term. Results show that DataCom can enhance controller performance (e.g., number of aircraft handled in the arrival sector) and reduce workload, however, the major improvement resulted from introduction of RNAV routes. These routes improve the utility of DataCom. When used together, routes and DataCom improve human-system performance substantially. DataCom potentially can improve the performance and utility of decision support tools by making them more accurate, which in turn decreases controller workload. (NextGen - Air Traffic Control/Technical Operations Human Factors (Controller Efficiency and Air Ground Integration))



DEFINED INITIAL REQUIREMENTS AND ANTICIPATED EFFICIENCY BENEFITS FOR MERGING AND SPACING DECISION SUPPORT TOOLS TO SUPPORT CONTINUOUS DESCENT APPROACH IN THE TERMINAL AREA

The program completed two merging and spacing efforts in the terminal environment in 2010. The first used a detailed approach to address human factors requirements for optimized profile descents and integrated arrivals and departures. This was an important step in analysis of proposed improvements to controller tasks and culminated in development of human-system integration requirements. The second effort was imbedded in the Future Terminal Workstation simulation to evaluate proposed use of decision support tools for merging and spacing. Included was conformance monitoring for adherence to routings such as the various types of continuous descent approaches. Researchers learned that use of such tools requires that conformance monitors and other alerting functions need a very low nuisance alarm rate to build a sense of trust in the automation. They also determined that the use of support tools would only be effective if the controller perceives that the tool provides a performance benefit. (NextGen - Air Traffic Control/Technical Operations Human Factors (Controller Efficiency and Air Ground Integration))

HUMAN-CENTERED DESIGN

Aerospace systems that adapt to,
compensate for, and augment
the performance of the human

GUIDEBOOKS FOR MANAGING AIRPORTS:

Under the auspices of the Airport Cooperative Research Program, the FAA developed the following guidebooks in FY 2010

- A practical, easy-to-use guidebook for managing small airports. The guidebook is designed to be useful to owners, operators, managers, and policy makers of small airports. To achieve this objective, the research:
 1. identifies fundamental management principles,
 2. identifies best practices for effective use and management of resources and facilities, and
 3. presents the information in an attractive, convenient format. A major element of this research is the identification of best practices that achieve safe and efficient operations while maintaining compliance with regulatory requirements and federal obligations.
- A guidebook for small airport marketing, external communications, and public information. The guidebook describes effective airport marketing practices, provides guidance in their use, and assists airports in developing an airport marketing strategy.
- A practical, user-friendly guidebook that:
 1. assists airport management in understanding the practical benefits of a performance-measurement system;
 2. identifies methods to help airports discern how well they are meeting their customer and stakeholder expectations;
 3. guides the development and implementation of the most appropriate performance-measurement system; and
 4. provides examples of key performance indicators, and how to incorporate them into a system. Performance-measurement systems resulting from this guidebook enhances the decision-making process to improve service and efficiency

(Airport Cooperative Research Program)

DEVELOPMENT OF A STANDARD COLOR PALETTE FOR AIR TRAFFIC DISPLAYS

The purpose of this task is to find a limited set of colors (12-15) that can be used to uniquely code information on computer driven Air Traffic Controller displays to be used in NextGen. The colors will be selected by a screening method that emphasizes the discrimination of each color by persons with normal color vision and with mild to moderate color vision deficiencies.

Currently, no clear standards are in use, and displays are free to select any color to represent similar display situations. Non-standard color use and changing usage could provide loss of signal salience for controllers both mildly color deficient and normally sighted. During 2010, consultation with researchers at the Civil Aerospace Medical Institute (CAMI) resulted in a list of 18 candidate colors that fit theoretical requirements of the selection. An empirical test evaluated 23 individuals (nine with color deficiency and 14 normal sighted individuals) using diagnostic and color discrimination tests. Data analysis will be completed in FY 2011. A calibration method that is cost efficient and simple to use in the field is being developed to ensure that color displays are consistent across displays. The colors selected will be theoretically and empirically grounded to provide a subset of display colors that must be used for key display functions, assuring standardization. (Air Traffic Control/Technical Operations Human Factors)

IDENTIFYING EQUIPMENT CATEGORIES FOR AVIONICS IN PREPARATION FOR HUMAN FACTORS EVALUATIONS OF NEXTGEN

In 2010, the FAA initiated a study to identify requirements for participating in the NextGen environment and to assess the existing fleet of US air carrier aircraft and flight deck avionics to determine their capabilities in light of NextGen requirements. Current avionic systems have performance capabilities that NextGen could leverage using complex operational procedures, but system designers did not necessarily include provisions for such complex procedures when designing the user interfaces for these systems. Present research focuses on human performance concerns associated with use of existing FMS and associated flight deck displays in NextGen procedures to identify mitigations and implications for aircraft certification. Data collection is complete and analysis is underway. (NextGen - Air Ground Integration Human Factors)

ELECTRONIC FLIGHT BAG (EFB) TECHNOLOGIES AND INTERFACES

Researchers helped the FAA address human factors issues related to EFBs, and supported development of EFB-related policies and guidance. The program conducted research to understand human factors issues related to implementation and integration of EFBs in normal flight operations. Two draft checklists for use during the review of EFB installations summarize the results. Researchers also published a technical report that identifies EFB issues, provides guidelines for integration of EFBs in operations, and examines EFB related safety reports from the public Aviation Safety Reporting System and NTSB. (Flightdeck/Maintenance/System Integration Human Factors)



AIRPORT MAP DISPLAYS

Researchers are working to understand what additional guidance and approval criteria is needed to establish minimum standards and best practices to support flight deck integration of surface moving maps depicting ownship position. Several advanced functions are under consideration – display of surface traffic, and alerts of potential runway incursions. In 2010, researchers conducted usability evaluations of three surface moving map software applications and identified potential human factors concerns in design. They provided technical support to an evaluation of the impact of a Surface Moving Map with ownship position on a Class 2 or Class 3 EFB. They also recorded observations to identify areas that may need human factors guidance to support development of Minimum Operational Performance Specifications for surface conflict detection and alerting. (Flightdeck/Maintenance/System Integration Human Factors)

PROACTIVE AUDIT APPROACH TO SUPPORT SAFETY MANAGEMENT SYSTEM IN AIRLINE MAINTENANCE AND RAMP OPERATIONS LINE OPERATIONS SAFETY AUDIT (LOSA)

Researchers are proactively studying airline maintenance and ramp operations during normal situations to develop Maintenance and Ramp LOSA processes. LOSA is a formal process wherein trained observers collect safety-related data on maintenance performance in a non-jeopardy environment. Information obtained via LOSA provides the maintenance organization a diagnostic snapshot of safety strengths and weaknesses. Proactive approaches, as opposed to post accident/event investigation, align with the principles of risk management and Safety Management System. In 2010, an FAA research team refined and finalized maintenance and ramp LOSA forms and procedures, and assisted with developing LOSA training materials. The team also completed tests of the forms and training materials with the assistance of industry personnel. A LOSA beta test was conducted November 7-12, 2010 with the Air Transport Association's Human Factors Committee and Alaska Airlines at the Alaska Airlines maintenance facility in Seattle. (Flightdeck/Maintenance/System Integration Human Factors)

MULTI-DISCIPLINARY APPROACH TO FATIGUE RISK MANAGEMENT IN AIRCRAFT MAINTENANCE – NEAR TERM AND NEXTGEN TIME FRAME (MAINTENANCE FATIGUE)

Current maintenance fatigue management processes used by Transport Canada, Australian Civil Aviation Safety Authority, European Aviation Safety Agency, and other regulatory organizations were analyzed and best practices were selected and evaluated in a prototype Maintenance Fatigue Risk Management System (RMS). The international best practices for fatigue risk management were documented in a technical report which is currently in review. Publication of "A Review of Best Practices in Fatigue Risk Management for Aviation Maintenance" is expected by late Spring 2011. In addition to providing the framework for a US RMS in maintenance fatigue, researchers developed prototype versions of each of the fatigue management tools proposed in the prototype system. The program will test the prototype systems against the fatigue research knowledge and the airline/maintenance operations to ensure that the systems can effectively manage maintenance fatigue. The program has also developed and distributed fatigue awareness materials (maintenance fatigue website, fatigue survival toolbox, hangar posters, maintenance fatigue newsletter). (Flightdeck/Maintenance/System Integration Human Factors)

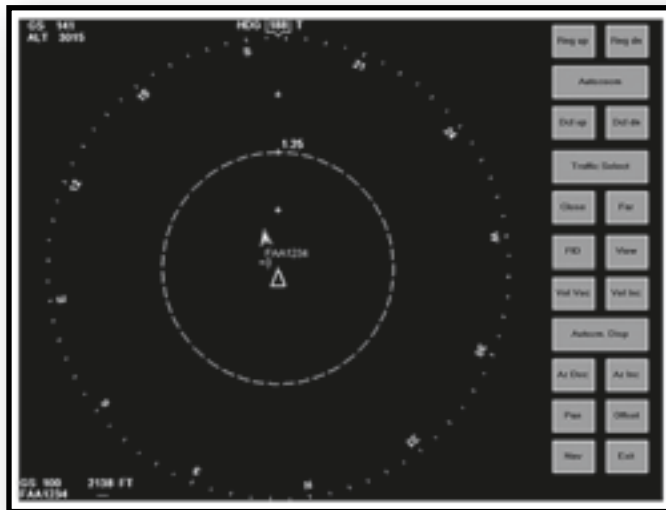


SYNTHETIC VISION FOR PRIMARY AND MULTIFUNCTION FLIGHT DISPLAYS

The objective of this project was to determine the potential effects on pilot performance of incorporating synthetic vision system (SVS) features into primary-flight and/or multifunction displays. In 2010, researchers conducted a literature survey to determine existing guidelines and standards for the design and use of pictorial imaging displays, including SVS, enhanced vision system (EVS), and primary flight displays. The survey also identified available data for both display design and human performance not captured in a guideline or standard. The team conducted a literature, industry, and product review, and developed a checklist summarizing human factors issues between SVS/EVS characteristics and pilot performance. They identified a number of references, documents, and guidelines that had direct or indirect bearing on human factors considerations involved in SVS, EVS, and primary flight displays. (Flight Deck/Maintenance/System Integration Human Factors)

AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST (ADS-B)

This research supports the FAA in understanding human factors issues related to use of Cockpit Display of Traffic Information (CDTI) based on ADS-B and other aircraft surveillance applications systems. At issue is the question whether symbols for CDTI should be required to match symbols used for the Traffic Alert and Collision



Avoidance System (TCAS) and whether CDTI should use the same “symbol-fill” as TCAS to represent the “proximity” of the target in range and altitude. Additional questions concern the value of the proximate status indication to pilots. In 2010 researchers examined the proximate status indication by presenting pilots with dynamic traffic simulations with and without the proximate status indication. Preliminary findings indicated that the proximate status indication did not improve the consistency of pilots’ ratings of traffic threat level and did not improve the consistency of pilot ratings

of their ability to visually acquire the target. Additionally, results suggest that pilots use the proximate status indication to prioritize their attention. Additional analyses are ongoing and will be presented to stakeholders in FY 2011. The FAA will consider the results in development of an update to the CDTI Technical Standard Order. (Flightdeck/Maintenance/System Integration Human Factors)

HUMAN PROTECTION

No fatalities, injuries,
or adverse health impacts
due to aerospace operations

FIRE HAZARDS INHERENT IN MICRO FUEL CELL CARTRIDGES

Portable electrical power is a necessity in the modern world. The uses for portable electrical power range from electronic devices such as cell phones and laptop computers to electric automobiles. Most often this takes the form of single use or rechargeable batteries. The trade off in any portable electrical power source is always capacity versus weight and volume. Batteries have limitations in the amount of electric energy that can be stored, though the battery industry continues to push these limits, allowing more and more capacity in a given weight and volume. Rechargeable batteries must be connected to an external source of electricity for recharging. Because charge times vary, rapid recharge is a key research goal.

Micro fuel cells provide an alternative to batteries as a portable source of electricity. A fuel cell is an electrochemical device that converts fuel and oxygen into electricity. The fuel is supplied in removable or refillable cartridges and can be of several different chemistries. The fuel cell extracts hydrogen gas from the base fuel. The hydrogen gas then reacts with oxygen from ambient air to produce electricity. The reacted hydrogen and oxygen results in water or water vapor as a byproduct.

In FY 2010, a series of tests were conducted to evaluate the flammability hazard of selected base fuels, that were tested as packaged in the original equipment as manufactured for consumer use where possible. The base fuels included gaseous hydrogen, liquid alcohols and acids, and granular borohydride compounds and mixtures. If the cartridges were not available, the fuel was tested in bulk form. The tests measured the response of the cartridge and fuel to an external, low-level fire source.

Most of the fuels tested were flammable. It was found that the cartridge material can have a significant effect on flammability. Metal cartridges protected the fuel from an external fire better than plastic cartridges. The cartridge containing formic acid did not ignite under test conditions. Butane produced the most vigorous fire. Hydrogen gas stored in a metal matrix is under low pressure and breaching of the enclosure allows the gas to escape and ignite. Borohydrides were difficult to ignite, but emitted a flammable fume when heated and were capable of deep-seated exothermic reaction. Halon 1211 was effective against all but the deep-seated borohydride exothermic reaction. The findings are detailed in the FAA report "Preliminary Investigation of the Fire Hazards Inherent in Micro Fuel Cell Cartridges," DOT/FAA/AR-09/53, by FAA researcher, Harry Webster. (Fire Research and Safety)

EVALUATION OF FIRE HAZARDS OF MAGNESIUM ALLOY SEAT STRUCTURE UNDER FULL-SCALE POST-CRASH FIRE CONDITIONS

In recent years, magnesium alloys have been suggested as a substitute for aluminum alloys in aircraft seat structure and other applications due to the potential for weight savings. The FAA has had several inquiries regarding the policy for using magnesium alloys in airplane cabins. Although magnesium alloys are routinely used in the construction of non-cabin aircraft components, they are currently banned from use in aircraft seats, according to FAA Technical Standard Order (TSO) -C127, "Rotorcraft and Transport Airplane Seating Systems." This TSO prescribes the minimum performance standards that rotorcraft and transport airplane seating must meet, including the qualification requirements and minimum documentation set forth in various sections of Society of Automotive Engineers, Inc. (SAE), Aerospace Standard AS8049, "Performance Standard for Seats in Civil Rotorcraft and Transport Airplanes," dated July 1990. Within SAE Aerospace Standard AS8049, revision A, paragraph 3.3.3 states that magnesium alloys shall not be used.



Flammability is the FAA's central concern regarding the use of magnesium and its many alloys in the cabin. The current regulations do not address the potential for a flammable metal to be used in large quantities in the cabin. Therefore, if such a material was introduced into the cabin, the FAA must be convinced that the level of safety would not be reduced. Recent developments in materials technology have shown that different magnesium alloys have different susceptibility to ignition. However, magnesium remains a material that,

once ignited, is very challenging to cope with using fire extinguishers currently available on aircraft.

To better evaluate their general flammability, the FAA conducted a preliminary assessment of several magnesium alloys using a laboratory-scale test rig. The test rig consisted of an oil-fired burner to simulate the fuel fire and a mounting mechanism to



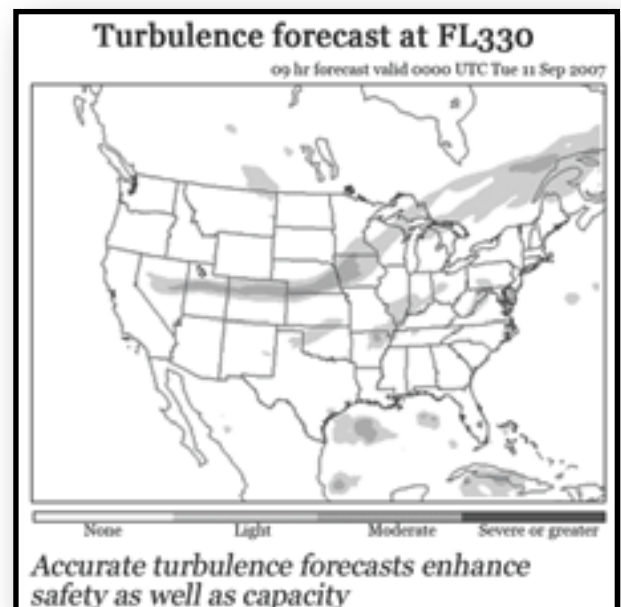
mount representative test samples. One sample was a prototype alloy containing rare earth elements to minimize flammability. The laboratory-scale tests indicated a large difference in flammability between the various samples tested. Magnesium alloys WE-43 and Elektron-21 both showed outstanding resistance to ignition when compared to the more traditional alloys such as AZ-31. Additional laboratory-scale tests evaluated the performance of handheld fire extinguishers against these same alloys when ignited.

Subsequent full-scale testing of these alloy systems provided useful information on the feasibility of using such materials in the primary components (cross-tubes, spreaders, and legs) of aircraft coach seating. Initial baseline tests using standard, Original Equipment Manufacturer aluminum-framed coach seats served as the backdrop to evaluate the performance of seats containing magnesium alloy components in the primary areas. During the testing, it was determined that the prototype WE-43 magnesium-alloy material produced no additional measurable hazard within the cabin, as temperature and toxic and flammable gases were no greater than those obtained during the baseline tests. Thus, in terms of postcrash fire survivability certain magnesium alloys are as safe as currently used aluminum alloys in aircraft seat structure. (Fire Research and Safety)

FORECASTING TURBULENCE

Turbulence accounts for 65 percent of all weather-related injuries, while only 35 percent of conditions are forecasted. Because observations and forecasts are not accurate enough to pinpoint the location, time, and intensity of turbulence, FAA-funded researchers developed the Graphical Turbulence Guidance (GTG) product. This product produces easy-to-interpret depictions of turbulence and provides the output on the Aviation Digital Data Service (ADDS) and the NOAAPort broadcast system. The web-based ADDS allows anyone with an internet connection access to the display, which shows relative turbulence intensities at user-selected altitudes.

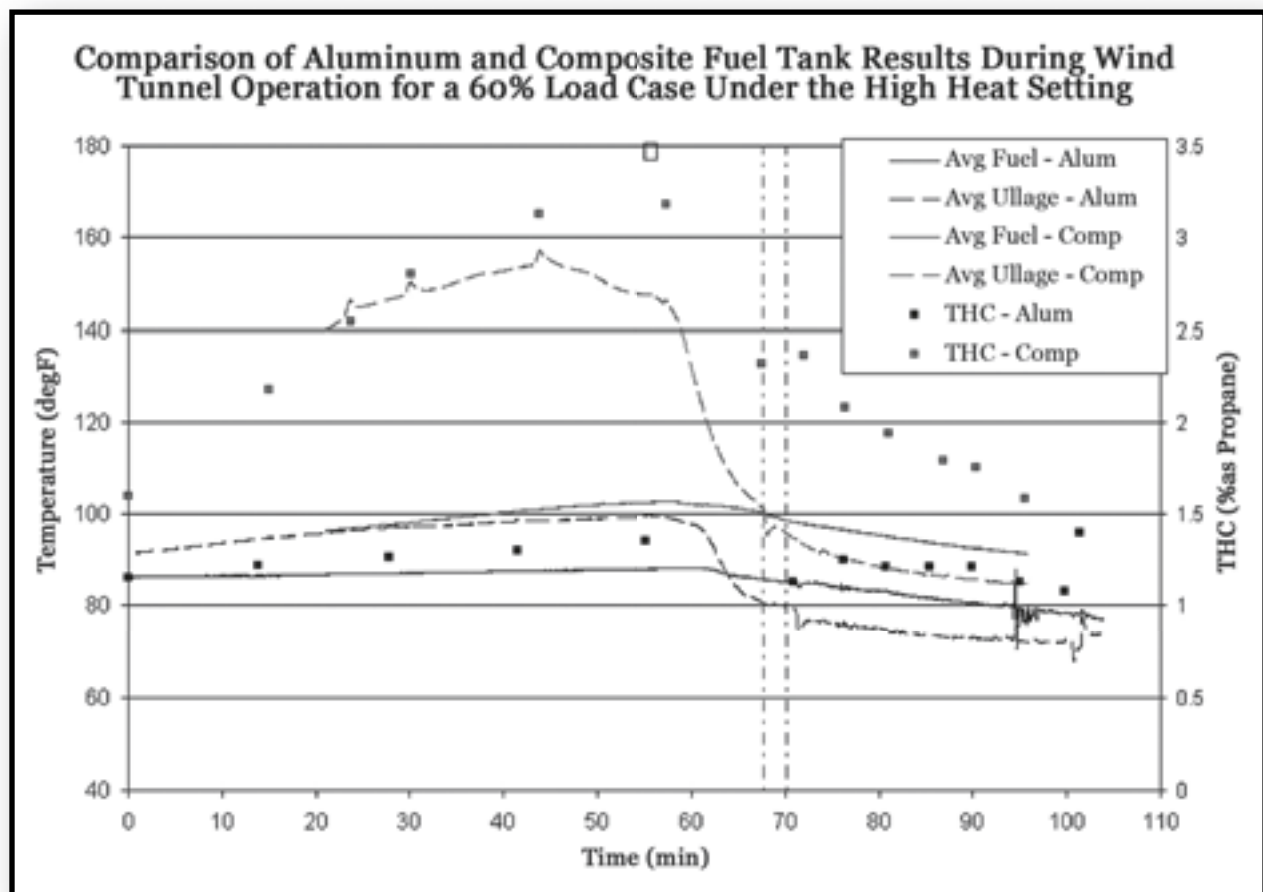
Using diagnostics computed from numerical weather prediction model forecasts, the GTG product provides contours of turbulence potential out to 12 hours. The current product, GTG2, operationally implemented on ADDS in FY 2010, and provides forecasts for clear air turbulence from flight levels 10,000 - 45,000. GTG2 is based on the NOAA's National Weather Service Rapid Update Cycle (RUC) meteorological model, which has a resolution of 20km. In early 2011, the RUC will be replaced by the Weather Research and Forecast - Rapid Refresh model which has a resolution of 13 km. A modification of GTG2 that takes advantage of the finer resolution forecasts, GTG2.5, will be implemented operationally at that time. GTG is an evolving product; future versions will provide forecasts for all flight levels, surface to 65,000 ft, and have the capability to forecast mountain-wave and convectively-induced (those in regions of thunderstorms) turbulence. (Weather Program)



A FLAMMABILITY COMPARISON OF COMPOSITE AND ALUMINUM FUEL TANKS UNDER SIMULATED GROUND AND FLIGHT CONDITIONS

The FAA has conducted a significant amount of research studying the flammability of traditional aluminum fuel tanks. This research, along with the development and demonstration of a fuel tank inerting system, has led to recent regulations requiring the reduction of flammability within high risk fuel tanks. Traditionally, fuel tanks located in the wing of an aircraft are considered to be of low flammability due to the rapid cooling that occurs in flight through the aluminum skin of the aircraft. However recent advances in composite materials have lead to an increase in the use of these advanced materials in aircraft construction.

FAA tests were performed at the FAA William J. Hughes Technical Center (WJHTC) using an environmental chamber as well as an air induction facility (wind tunnel) to examine the variation in flammability exposure of a fuel tank consisting of a composite material skin versus that of a traditional aluminum skin.



The results from the testing in the environmental chamber showed that the top skin temperature for the composite tank reached much higher temperatures when subjected to the same radiant heat source. This increased skin temperature caused internal ullage and fuel temperatures to be much greater for the composite skin tank and resulted in significantly higher total hydrocarbon (THC) measurements. The aluminum fuel tank never reached the accepted lower flammability limit of approximately 2.0 percent during the entire five-hour heating cycle. In contrast, the tank with composite skin reached the flammable limit after approximately 45 minutes of heating and reached a peak THC of more than twice that of the aluminum tank.

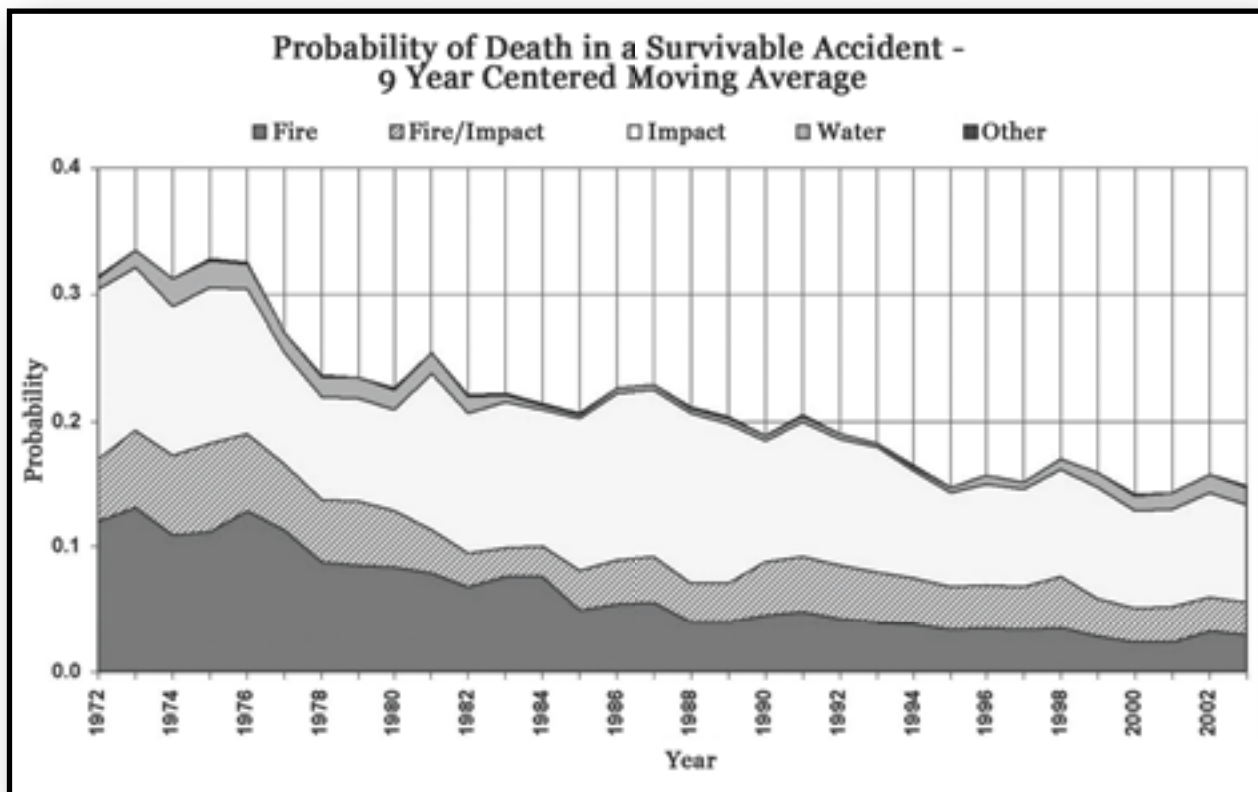
Testing in the air induction test facility showed similar changes in initial temperature and THC profiles. In each of the tests, the ullage temperature in the composite tank was between 40-60 °F higher than those from the aluminum tank tests. The average fuel temperatures however varied by only 10 °F and show much less of a temperature increase than the ullage. THC measurements in each of the aluminum tank tests varied only very slightly throughout the full length of the test, whereas extremely large increases were observed in the composite tank tests.

As air flow through the wind tunnel began, decreases in both ullage and fuel temperature were observed. The largest decrease seen was in the ullage temperature of the composite skin tank as this had the largest temperature differential relative to the ambient. THC measurements in the aluminum tank tests showed minimal change, while measurements in the composite tank tests showed a significant decrease due to the large decrease in ullage temperature. Even with this rapid decrease in THC, however, the fuel tank remained in the flammable region for a significant amount of time, up to 25 minutes after the 90 percent throttle position of the wind tunnel was reached. From the data shown, it is clear that there is a significant increase in flammability exposure of a composite skin fuel tank from that of a traditional aluminum skin fuel tank. (Fire Research and Safety)

AN ANALYSIS OF TRENDS IN SURVIVABILITY AND FATALITIES IN WORLD-WIDE TRANSPORT AIRCRAFT ACCIDENTS

An in-depth analysis of transport aircraft accidents was conducted to quantify the improvement in safety over the past 40 years in terms of a reduction in accidents and an improvement in survivability in those accidents deemed to be survivable. A survivable accident was defined as an accident that is not non-survivable (all the occupants sustain fatal injuries) but in which at least one fatality occurred or the airplane was destroyed. Of particular interest was the trend regarding fatalities attributable to fire in survivable accidents, because of the aircraft improvements derived from fire research activities that were implemented through the regulatory process over the past 25 years.

The study analyzed 1036 world-wide accidents (of which 672 were survivable) that occurred between 1968 and 2007 involving large transport category turbojet and turboprop western-built aircraft operating in a passenger or passenger/cargo role. In 224 of the survivable accidents, the occupants were subjected to both impact and fire, and in 157 of these accidents, the cause of death could not be determined for all occupants. In such cases, the fatalities were randomly assigned to impact, impact and fire, or fire in a proportionate manner over the known possible range.



The annual number of accidents and survivable accidents for the world-wide fleet of western-built aircraft exhibited a significant decrease since the mid-1990s despite the large increase in the annual number of flights. This decline was also exhibited by the US and Canadian fleets, beginning earlier in the late 1980's. The reduction is apparent when the accident rate was measured on per flight, per passenger, or per revenue passenger mile basis. For example, the number of total accidents world-wide per million departures decreased from 1.6 in 1990 to about 0.7 in 2005. For the US and Canadian fleets the accident rate reduction was most pronounced since 1990, decreasing from about 0.9 to 0.15 in terms of accidents per million departures.

The survivability of accidents has also shown a marked improvement over the study period with a greater proportion of accidents being survivable and a marked increase in the proportion of occupants surviving an accident. Over the study period there has been a steady improvement in the probability that an accident will be survivable, increasing by about 40 percent; presently, about 75 percent of world-wide accidents are survivable. The improvement in survivability has also been dramatic, as measured by the probability of death in a survivable accident. That probability has improved by a factor of two, i.e., decreasing from about 0.3 to about 0.15. These overall improvements are also evident in the combined US and Canadian fleets.

Surviving the effects of fire has improved considerably, as shown in the accompanying graph. This improvement is most evident in terms of the probability of death from fire in a survivable accident and, to a lesser degree, the proportion of fatalities attributable to fire in survivable accidents. The probability of death from fire has improved by a factor of three, decreasing from about 0.12 to about 0.04. Also, the proportion of fire fatalities has decreased from about 40 percent to about 23 percent.

The findings from this study are documented in FAA Report DOT/FAA/AR-10/16, "Trends in Accidents and Fatalities in Large Transport Aircraft." The study was requested by the Cabin Safety Research Technical Group (CSRTG), comprised of representatives from the regulatory authorities, and was jointly funded by FAA and Transport Canada. Both the report and the CSRTG accident data base are available on the FAA Fire Safety Team web site at www.fire.tc.faa.gov. (Fire Research and Safety)

SUPPORT OF AIRCRAFT ACCIDENT INVESTIGATION

During the investigation of aviation accidents, postmortem specimens from accident victims are submitted to the FAA's CAMI for toxicological analysis. The first, and perhaps most important, step in the analysis process is the initial screening of biological specimens for illicit, medically prescribed, and over-the-counter compounds that may be present and could have been the cause of the accident. This screening is currently performed by biochemical procedures such as the General Unknown Screening (GUS) procedure, which involves gas chromatography/mass spectrometry (GC/MS), liquid chromatography/diode array detection (LC/DAD), and fluorescence detection techniques.

GC/MS techniques have inherent limitations that prevent the detection of certain types of compounds. LC/DAD is more limited due to poor sensitivity (e.g., in detecting a compound) and specificity (e.g., difficulty in differentiating a compound from another). Therefore, CAMI laboratory developed and validated an LC/MS/MS procedure that provides far superior sensitivity and specificity to that of LC/DAD.

The most common detector used in conjunction with LC is the DAD. Diode array detectors provide ultraviolet (UV) spectra for compounds that absorb UV radiation. These spectra are generally compound-dependent and can, therefore, be placed in a library and used for identifying unknown compounds in a specimen. However, DAD is not as specific as MS. Numerous compounds may have spectra that look similar, making identification tedious, and this method of detection cannot identify compounds with no UV absorbance. In recent years, the combination of LC with MS has become increasingly prevalent in many laboratories. This combination provides an almost universal separation technique and the most sensitive and specific detector allowing for the detection of a wider variety of compounds than either GC/MS or LC/DAD alone. LC/MS will play a significant role in the future of GUS. Laboratories around the world have begun the process of phasing out LC/UV and replacing it with LC/MS methodology. The CAMI Forensic Toxicology Research laboratory created and validated an LC/MS/MS method, and an associated library of compounds for use as a part of their GUS procedure. The combination of GC/MS with LC/MS/MS will allow for the detection of more compounds at lower concentrations than current techniques, thus, improving methods to support accident investigation efforts. The study's findings are available in Report No. DOT/FAA/AM-10/8, "General Unknown Screening by Ion Trap LC/MS/MS" by R.D. Johnson (Aeromedical Research)

EVALUATION OF THE HUMAN RESPONSE TO HYPOXIA TRAINING ENVIRONMENTS

Skepticism has existed for decades whether normobaric (i.e., at ground level) and hypobaric (i.e., at altitude) hypoxic exposures are equivalent. This question is important in terms of clinical practice and training measures for aircrew to assess their own hypoxic symptoms. CAMI Environmental Physiology research personnel evaluated if physiological differences between the two environments would translate into actual differences in hypoxia symptoms.

Twenty human volunteer research subjects were exposed to five-minute 25,000-ft equivalent environments in an altitude chamber and then in a ground-level reduced-oxygen enclosure (PROTE). Heart rate and hemoglobin oxygen saturation (SAO₂) were continuously monitored to assess the physiologic state of the subjects. Alveolar (pulmonary) gas samples were also collected at one-, three-, and 4-minute elapsed time after the exposure. Subjects completed questionnaires indicating their hypoxia symptoms at the same time points.

Mean 4th minute alveolar oxygen tension, alveolar carbon dioxide tension, and respiratory quotient (RQ) values differed significantly between the altitude chamber and PROTE. Declines in SAO₂ appeared biphasic (occurring in 2 phases), with the steepest declines seen in the first minute. Rates of SAO₂ decline over the 5-minute exposure were also significantly different between the chamber and PROTE. Heart rate was not different, even when indexed to body surface area. Differences in mean number of hypoxia symptoms between hypobaric and normobaric environments after 1 minute were significant. However, the temporal pattern of symptom frequencies across subjects between the chamber and PROTE were similar. For example, differences in mean number of hypoxia symptoms between hypobaric and normobaric environments after one minute, but not at three and four minutes, coupled with similar patterns in symptom frequencies, suggest that ground-level hypoxia training may be a sufficiently faithful surrogate for altitude chamber training. Alveolar gas composition, as well as arterial hemoglobin oxygen desaturation patterns, differed between a ground-level and hypobaric exposure to a simulated altitude of 25,000 ft. The study's findings will aid in the formulation of training programs that address hypoxia as an environmental stressor. The results of the study have been submitted for publication in the *Journal of Aviation Space and Environmental Medicine* and as an Office of Aerospace Medicine report as "A Test of Physiological Equivalence of Normobaric and Hypobaric Exposures of Humans to 25,000 Feet" by Self DA, et al. (Aeromedical Research)

TOXICOLOGICAL FINDINGS IN FATALLY INJURED, OBESE PILOTS INVOLVED IN AVIATION ACCIDENTS

Obesity continues to be a public health concern and its impact on aviation community has not been fully evaluated. Toxicological findings in obese pilots who were fatally injured in aviation accidents were examined. CAMI's Scientific Information System, developed by the Bioinformatics Research laboratory, was used to identify a dataset, entailing fatally injured, obese pilots involved in aviation accidents from 1990 to 2005. A pilot with a body mass index of $> 30 \text{ kg} \cdot \text{m}^2$ was considered obese.

Toxicological results and aeromedical histories of these aviators were retrieved from the CAMI toxicology and medical certification databases, and the cause/factors in the related accidents were retrieved from the NTSB aviation accident database. In 311 of the 889 pilots, carbon monoxide, cyanide, ethanol, and drugs were found, and glucose and hemoglobin A1c were elevated. Many of these drugs were for treating overweight, depression, hypertension, and cardiac conditions.

Of the 889 pilots, 107 had an obesity-related medical history. The health and/or medical condition(s) of, and/or the use of ethanol and/or drugs by, pilots were the cause or factored in 55 (18 percent) of the 311 accidents. Although the drugs found are commonly used in the general population, they were primarily used for treating obesity-related medical conditions. Findings emphasize monitoring of obesity and diabetes in pilots and understanding the potential implications of these health conditions in relation to flight safety. The study's findings are available as Report No. DOT/FAA/AM-10/10, "Toxicological Findings in 889 Fatally Injured Obese Pilots Involved in Aviation Accidents" by A.K Chaturvedi, et al. (Aeromedical Research)

EVALUATING PROBABILISTIC RISK ASSESSMENT METHODOLOGY FOR USE IN THE MEDICAL CERTIFICATION OF AIRMEN

People make risk informed decisions every day. The simple assessment to drive a car to work involves a subjective risk calculation. The likelihood of having an adverse outcome, such as an accident, weighs into each individual's decision to drive. Usually this is considered an acceptable risk, but there are circumstances where the risk is considered too high. During icy or bad weather conditions, an individual may deem the risk too great to drive and may wait until more favorable conditions prevail. With complex systems and processes, risk-informed decision making becomes much more difficult. Probabilistic Risk Assessment (PRA) is a methodology designed to evaluate hazards and make possible risk-informed decisions in a complex environment.

The collaborative approach taken with the PRA and other agencies such as NASA, the Nuclear Regulatory Commission, US Coast Guard, US Army, and associated contractors led to the formation of the Medical and Performance Risk Working Group (MPRWG). The MPRWG represents a partnership among government agencies which have a need for mitigating risk in their operations. This partnership analyzes the strategies and discusses possible solutions for a number of likely scenarios which might be encountered within day-to-day operations.

Within a PRA, risk consists of the severity of an adverse event along with the likelihood of its occurrence. The FAA Office of Aerospace Medicine is learning from these PRA applications in an effort to integrate risk-informed decision making into some of its own processes. Like the healthcare industry, determining risk assessment in the medical certification of pilots is a more complex task than determining the shifting probabilities of hardware or component malfunction. It is expected that implementation of a PRA approach to a process as large as the national certification of airmen should reap many benefits including a risk-informed approach to decision making. More information regarding PRA processes is available in "Evaluating Probabilistic Risk Assessment Methodology for use in the Medical Certification of Airmen" by P.B. Rogers, Aviation, Space, and Environmental Medicine Journal, 2010; 81(10): 904-905. (Aeromedical Research)

SAFE AEROSPACE VEHICLES

No accidents and incidents
due to aerospace vehicle design,
structure, and subsystems

BURNING OF AIRCRAFT CABIN MATERIALS IN THE VERTICAL FLAME TEST

The vertical flame test for cabin and cargo compartment materials is used to determine the ignition resistance of materials held in a vertical orientation and subjected to a Bunsen burner flame for 12- or 60-seconds as specified in Federal Aviation Regulation (FAR) 25.853 and FAR 25.855. Aircraft cabin materials affected by the 60-second vertical Bunsen burner (VBB) exposure requirement include interior ceiling panels, wall panels, partitions, galley structure, large cabinet walls, structural flooring, and stowage compartments and racks. Materials affected by the 12-second VBB exposure requirement include floor covering, textiles including drapery and upholstery, seat cushions, padding, coated fabrics, leather, trays, galley furnishings, electrical conduit, thermal and acoustical insulation, insulation covering, air ducting, joint and edge covering, liners of Class B and E cargo or baggage compartments, floor panels of Class B, C, D, or E cargo or baggage compartments, insulation blankets, cargo covers and transparencies, molded and thermoformed parts, air ducting joints, and trim strips. The vertical Bunsen burner tests in FAR 25.853 and FAR 25.855 place strict limits on the duration (< 5 seconds) and extent (< 20 cm) of burning of the affected aircraft cabin materials. Despite these strict limits on upward flame spread and the wide range of cabin materials affected by this regulation, little is known about the relationship of material properties to the test results that would allow extrapolation to other fire scenarios using engineering models or the design fire safe cabin materials. To this end, a joint study was conducted at the University of Maryland Department of Fire Protection Engineering and the FAA WJHTC to relate the upward burning of plastics to their material fire properties.

It was shown that, following a brief period of ignition in the Bunsen burner (12 or 60 seconds), the heat flux from the sample flame is the driving force for sustained upward burning. The flame heat flux is proportional to the heat release rate per unit area of the burning sample above a critical value of 80 kW/m² for ignition, 250 kW/m² for sustained burning, and 300 kW/m² for upward spread of flame. It was also shown that fire properties of materials that could be measured in fire calorimeters including the heat release parameter (HRP), the critical heat flux (CHF) for piloted ignition, and the thermal response parameter (TRP) could be used to correlate the fire behavior of plastics in the VBB test. This is an important finding because these same material properties (HRP, CHF, TRP) determine the rate of fire growth in compartments such as aircraft cabins under severe heat flux conditions. (Fire Research and Safety)

NEW DEVELOPMENTS IN TURBINE ENGINE COMPONENT RISK ASSESSMENT SOFTWARE

Over the past few decades, a number of uncontained aircraft engine failures have been traced to atypical material anomalies in the rotating components of aircraft gas turbine engines. Since the occurrence rates are relatively small, a probabilistic approach is used to assess the risk of fracture including the potential risk reduction associated with non-destructive inspections. Over the past several years, the FAA has issued several Advisory Circulars to address life-limited engine parts (AC 33.70-1), including those with inherent material anomalies (AC 33.14-1) and induced anomalies associated with surface damage (AC 33.70-2). The associated risk of fracture can be predicted using Design Assessment of Reliability With Inspection (DARWIN®), a probabilistic fracture mechanics software code developed by Southwest Research Institute under FAA R&D funding.

A number of new capabilities were implemented in the most recent release (DARWIN 7.1) that provides improved risk assessment of turbine engine components. For example, a new High Cycle Fatigue (HCF) Threshold Check capability was introduced in Version 7.1 that allows the user to include the influences of vibratory (HCF) stresses in fatigue crack growth and fracture risk computations (see figure 1). Fracture is assumed to occur when the stress-intensity factor associated with the HCF stress exceeds the HCF fatigue crack growth threshold value. The HCF threshold check is performed once per mission in conjunction with the application of the peak Low Cycle Fatigue stress in the mission.

A new capability for automatic generation of life contours was developed in DARWIN 7.1 for application to two-dimensional (2D) finite element models (see figure 2). When the user executes this option, an anomaly of one or more user-specified sizes is automatically placed at each of the nodes in the finite element model. The automatic geometry model process (introduced in DARWIN 7.0) generates a fracture model at each anomaly location, and then the fatigue crack growth (FCG) lifetime to failure is computed for each model. The resulting family of calculated life results is displayed in the graphical user interface using conventional contouring methods, as is often done for stresses. The figure demonstrates that the stress hot spots (dark regions of high stress) do not correspond exactly with the life hot spots (regions of low FCG life) due to the additional geometry factors that influence FCG life. Further details on this new capability are provided in the DARWIN User's Guide (www.darwin.swri.org). (Propulsion and Fuel Systems)

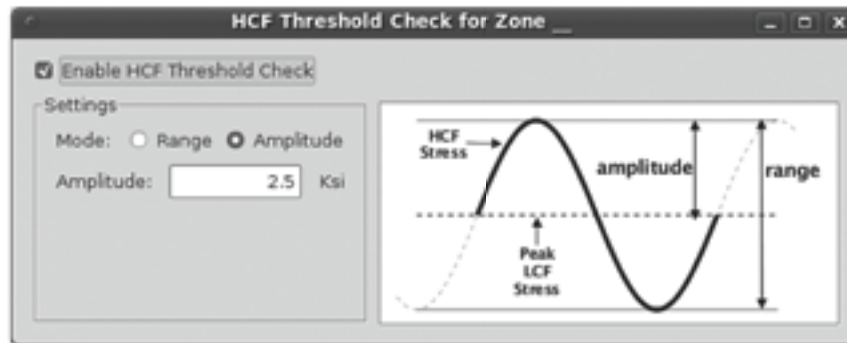


Figure 1: A new HCF Threshold Check capability was introduced in Version 7.1 that provides treatment for vibratory (HCF) stresses.

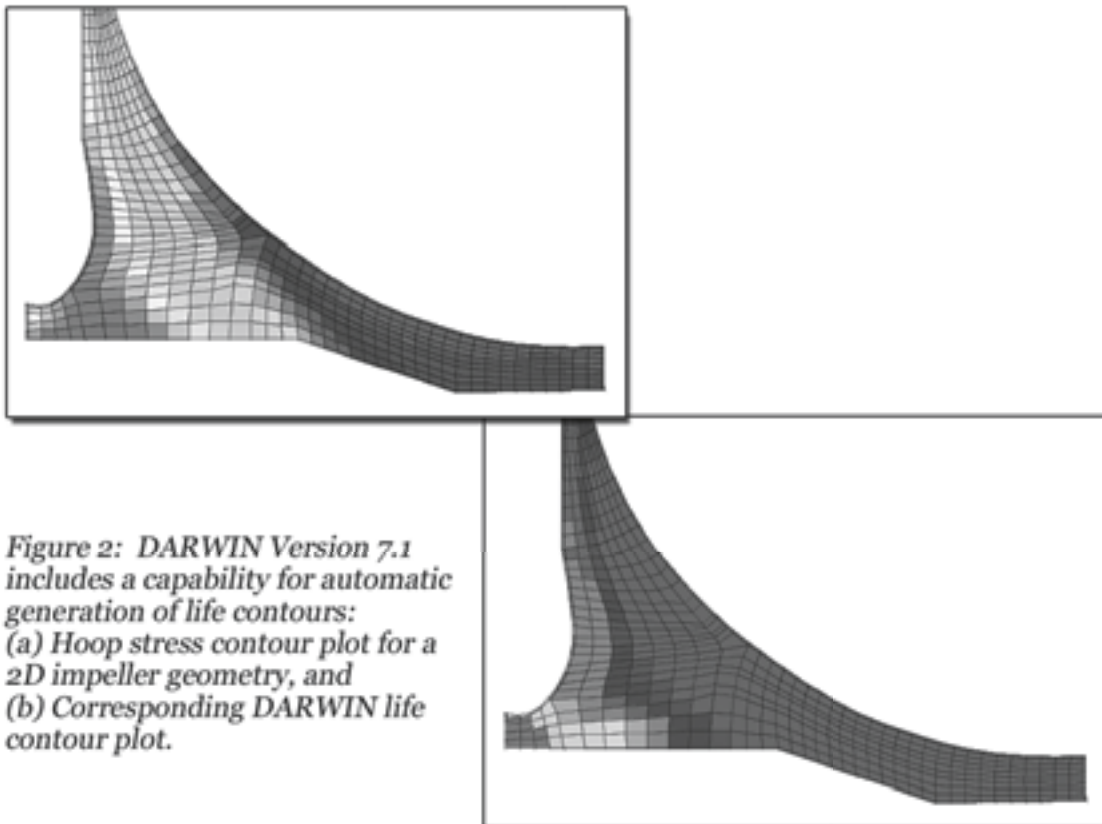


Figure 2: DARWIN Version 7.1 includes a capability for automatic generation of life contours: (a) Hoop stress contour plot for a 2D impeller geometry, and (b) Corresponding DARWIN life contour plot.

MODELING WING TANK FLAMMABILITY

The FAA has studied center wing fuel tank (CWT) flammability and fuel tank inerting extensively, which resulted in the FAA releasing a final rule requiring the reduction of flammability in high risk fuel tanks. The study of fuel tank flammability was driven mostly by the desire to understand the conditions under which the catastrophic mid-air breakup of TWA flight 800 took place. This incident occurred soon after takeoff from John F. Kennedy International Airport in New York in July 1996. Accident investigators from the NTSB determined the cause of the crash was an explosion in the nearly empty CWT that was initiated from an unconfirmed ignition source. The explosion occurred in part due to the fact that combustible vapor was being generated in the CWT due to heating of the bottom surface of the fuel tank by the heating ducts and air cycle machines of the airplane.

Continued study of commercial transport fuel tank flammability is critical to understanding the conditions under which an airplane could have a catastrophic explosion. Previous tests have shown that wing fuel tanks can also become flammable under some conditions occurring in the commercial transport airplane fleet. To study this, an investigation into the flammability of a wing fuel tank was performed. A computational model was developed to predict the evaporation of vapor from the liquid fuel into the ullage of a wing fuel tank. The model predicts the flammability evolution within a fuel tank ullage based on the ground and flight conditions of a wing fuel tank. The model was compared with data from supporting experiments performed in an altitude chamber, a wind tunnel facility, and a series of flight tests.

Experimental results from the altitude chamber compared well with computational data, particularly when comparing the data trend data, but compared best when computational results were generated with a lower flashpoint fuel. This could be due to the replenishment of species with lower flash point at the surface of the fuel which emulates the flash point of the entire fuel to be lower. Experimental results for the aluminum wing tests from wind tunnel experiments are in good agreement with the computational results as well.

A simpler model was developed from a program that calculates fuel air ratio within the ullage of fuel tanks to reduce the required number of inputs to the model. This model was applied to the data sets for the experiments performed in the altitude chamber and wind tunnel. For the tests conducted in the altitude chamber, the correlation estimates the hydrocarbon concentrations extremely well during ascent and descent, but not as well during the ground conditions. For the tests conducted in the wind tunnel, the computational values follow the general trend of the experimental values, but the computational values consistently estimated the total hydrocarbon concentration approximately 10 percent lower than the experimental value.

For the temperature and pressure profiles considered in this work, it was found that the temperature and pressure effects on the flammability limits are minimal. In contrast, the oxygen concentration has a significant effect on the flammability limits of the vapor; the flammable region narrows with a decrease in oxygen concentration. (Fire Research and Safety)

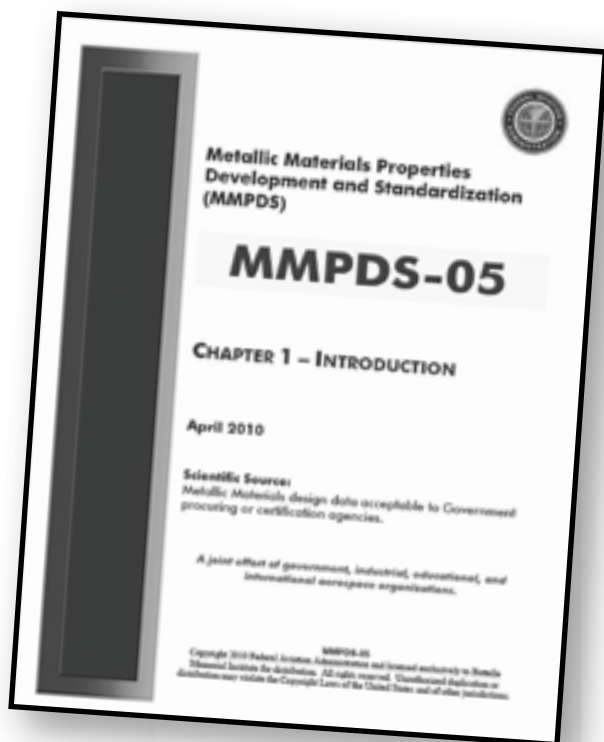
GENERIC HOLDOVER TIMES GUIDELINES

In Sept. 2010, the FAA developed generic holdover time guidelines and allowance times and technical guidance for aircraft winter operations for use by the world's airlines during winter 2010-2011. Information is incorporated into Flight Standard's Annual Ground Deicing Notice issued in the fall. (Atmospheric Hazards-Aircraft Icing/Digital Systems Safety)

METALLIC MATERIALS PROPERTIES DEVELOPMENT AND STANDARDIZATION (MMPDS)

The MMPDS is an effort led by the FAA to continue the Handbook process entitled "Metallic Materials and Elements for Aerospace Vehicle Structures," (MIL-HDBK-5). The Handbook is recognized worldwide as the most reliable source for verified design allowables needed for metallic materials, fasteners, and joints used in the design and maintenance of aircraft and space vehicles. Consistent and reliable methods are used to collect, analyze, and present statistically based aircraft and aerospace material and fastener properties.

The objective of the MMPDS is to maintain and improve the standardized process for establishing statistically-based allowables that comply with the regulations, which is consistent with the MIL-HDBK-5 heritage, by obtaining more equitable and sustainable funding sources. This includes support from government agencies in the Government Steering Group, from industry stakeholders in the Industry Steering Group and from profits selling the Handbook and derivative products. Toward this goal, the commercial version of the MMPDS-05 was released April 2010. There has been a substantial upgrade with approvals from the 15th through the 17th MMPDS General Coordination Meetings. (Continued Airworthiness)

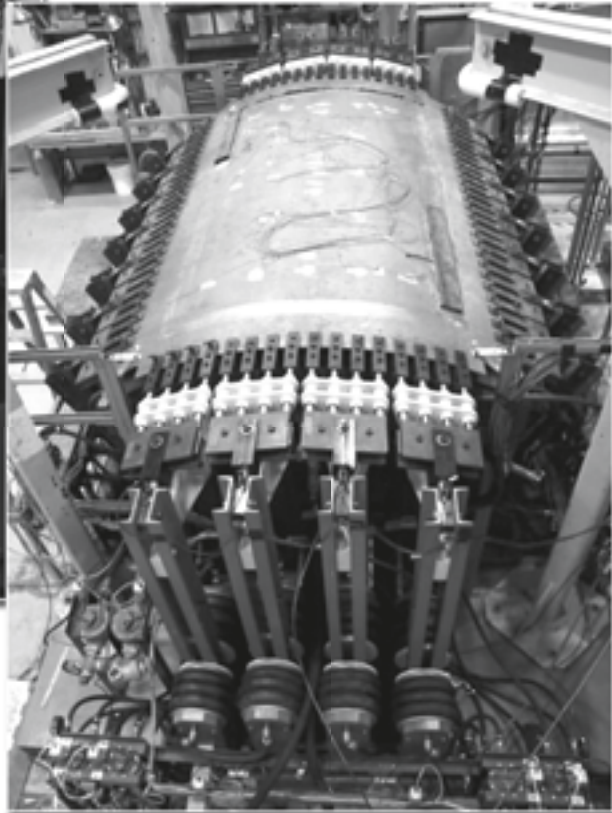


MODIFICATIONS TO THE FAA'S FULL-SCALE AIRCRAFT STRUCTURAL TEST EVALUATION AND RESEARCH (FASTER) FACILITY

On March 5, 2010, enhancements to the FAA's FASTER fixture were verified for axial tension-compression loading capabilities. This unique feature was added to the fixture as part of the Cooperative Research and Development Agreement (07-CRDA-0236) between the FAA and the Boeing Company, a cost-share arrangement leveraging resources to conduct research into areas of safety and structural integrity of bonded repairs and advanced stitched composite technology. The new capability is being used to gain a better understanding of the durability and damage tolerance aspects of bonded repair technology to fuselage structure. (Continued Airworthiness)



Modifications to FAA's FASTER fixture for axial tension-compression loading capabilities.



ENGINE CONTAINMENT ANALYSIS

In 2010, the Aircraft Catastrophic Failure Prevention Program (ACFPP) continued research to develop a new material model for the LS-DYNA explicit finite element code which can be used for modeling engine fragment impact in aircraft. Improved modeling supports an overall goal to have a publicly available analysis tool with standardized generic models, user guides, training, software quality control process, and validated material models. This will allow FAA engineers to validate the proprietary tools, streamline the certification process, and help mitigate fatalities and injuries when these events occur. This material model is designed to more accurately predict different failure modes than existing models to date. This material model is also being supported by the FAA/NASA/Industry LS-DYNA Aerospace Quality Control Working Group involved in modeling engine impact and failure events.

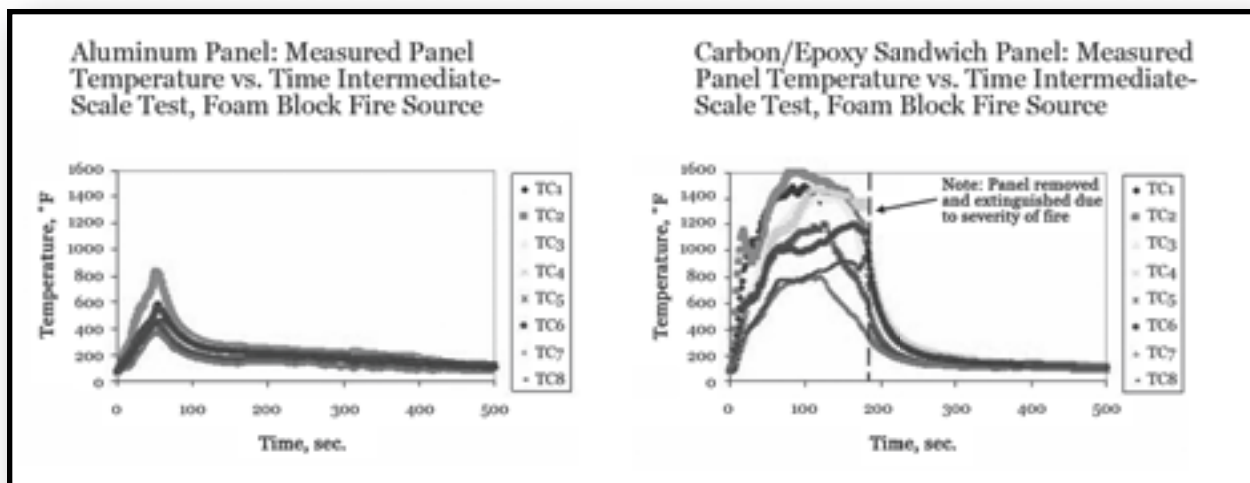
In 2010, in coordination with NASA, George Washington University, and Ohio State University collaborating with the LS-DYNA Aerospace Users Group, the ACFPP has completed the development of a failure material model for aluminum 2024 based upon plastic flow stress theory. This model is fully coded into LS-DYNA as MAT224 (Tabulated Johnson-Cook). This is a significant improvement over the previous industry model known as the MAT15 (Johnson-Cook) failure theory which also is plastic flow stress theory. The new model takes advantage of the exponential growth of computing capabilities and leverages inexpensive computer memory by programming actual failure data for various tests. The novel connection of stress state to the data is performed with a series of parameters based upon the individual stress states of the finite element known as triaxiality, and lode-angle to create a failure surface. Testing has been performed, and the original failure surface has been generated. The model is performing well and is the first to be able to predict multiple failure modes without being re-tuned to the new failure condition. Development and validation of the model with regularization for aluminum and titanium is on track for completion in 2013. (Aircraft Catastrophic Failure Prevention)

DEVELOPMENT OF A FLAMMABILITY TEST METHOD FOR THE IN-FLIGHT FIRE RESISTANCE OF COMPOSITE FUSELAGE STRUCTURAL MATERIALS

Currently, to certify an aircraft with a composite fuselage, the manufacturer must demonstrate that the composite materials will provide an equivalent level of safety to an aluminum-constructed aircraft when exposed to an in-flight fire. This is done by obtaining special conditions from the FAA, where the applicant submits a test plan for review, performs testing and analysis, and provides the results to the FAA, the FAA then determines whether the composite material does not present any increased safety hazard compared to aluminum.

To standardize and simplify the certification process for composite aircraft, in 2010, a study was undertaken by the FAA to develop a laboratory-scale test method for determination of flame propagation of composite fuselage materials. The test method was designed to correlate to an intermediate-scale test simulating a moderately severe hidden fire impinging on the inboard side of the aircraft skin.

In the study, an intermediate-scale test rig was constructed to simulate an inaccessible area in an aircraft cabin with the ability to interchange the test panels to study various composite materials. A wide variety of materials were tested, including several types of carbon/epoxy panels, including aerospace and non-aerospace woven laminates, uni-directional laminates, and carbon/epoxy structural plies bonded to a honeycomb core. Other materials tested include glass-fiber reinforced polyester, glass-cloth epoxy resin, and a baseline aluminum panel. The standard hidden fire source employed to develop improved flammability test methods for insulation, ducting, and wiring was used in the test rig, consisting of a polyurethane foam block spiked with a small amount of heptane to promote uniform, consistent burning. The simulated hidden area was insulated with ceramic fiberboard to retain heat produced from the burning foam block and direct it towards the test panel. Panel temperatures were recorded during each test with thermocouples located on the inboard-side of the test panels in an attempt to quantify the progress of the flame along the panel surface, as shown in the figure on the next page. Video was taken to study the duration and intensity of panel burning, and a post-test measurement of the burn area was recorded. Materials were ranked according to burn length and burn time after foam block extinguishment.



The radiant heat panel fire test apparatus was used as the laboratory scale test since it had been determined to be an appropriate improved flammability test for other hidden materials. Radiant panel test parameters were varied until the intermediate-scale ranking was achieved. This was accomplished by constructing a sample holder to align the test sample parallel to the radiant heat panel, pre-heating the sample in this position for one minute, and applying the pilot flame for 15 seconds.

The results will be documented in an FAA Technical Report. The resulting test method, or a variation of, will be adopted and used for the Part 25 Appendix F re-write rulemaking activity by the FAA Office of Aviation Safety, Transport Directorate, which aims to enhance the fire safety of materials in inaccessible areas of aircraft while also simplifying and reorganizing the regulations. (Fire Research and Safety)

SEPARATION ASSURANCE

A reduction in accidents
and incidents due to
aerospace vehicle operations
in the air and on the ground

THE NEXTGEN – SELF-SEPARATION HUMAN FACTORS PROGRAM

In FY2010, the program continued development of human factors scientific and technical information to implement NextGen capabilities. Research addressed human performance and coordination among pilots and (ANSP), human system integration, and error management strategies. The research supports AVS specialists who establish the standards and policies for NextGen operations, certify compliance with those standards, and assure continued operational safety once the adoption of new aircraft technologies generates procedure changes for flight crew and controllers. It also supports NextGen OIs leading to reduced and delegated self-separation, including ADS-B enabled applications (Oceanic in-Trail Procedures or OTP, Interval Management or IM, and CSPO) and Equivalent Visual Operations (EVO), among others.

The NextGen – Self-Separation Human Factors Program, initiated in FY 2009, has defined more than two dozen research projects to support its objective, and FY 2010 research produced detailed R&D plans that will be complete by FY 2011. These R&D plans outline the human factors efforts required for successful implementation of NextGen Operational Improvements (OIs) for specific reduced and delegated separation applications. As a result of FY 2010 research, key planned products include descriptions of research and operational experience for each of the application areas, technical information in specialized topic areas such as flight crew training for advanced NextGen flight deck automation, and identification of human factors challenges posed by the current implementation of the Navigation Reference System, a precursor system enabling trajectory operations under NextGen.

Anticipated outputs include:

- Defining the potential impact and human factors issues due to new technologies such as enhanced vision, synthetic vision, and electronic flight bags on separation activities
- Defining human factors technical information needed to support the development of standards, procedures, and training by FAA Flight Standards to implement plans for reduced aircraft separation and recovery to classic air traffic operations due to abnormal events
- Developing procedures and training needed to implement new roles and responsibilities for pilots and controllers during delegated separation operations
- Defining human and system performance requirements for separation activities, e.g., spacing, merging, and passing
- Developing and applying error management strategies and risk mitigation factors to reduce automation-related errors associated with enhanced separation operations
- Developing human factors criteria for the successful use of flight deck performance monitoring and decision support tools as they relate to enhanced separation maneuvers such as spacing, merging, and passing; and determining how conformance alerts are communicated and resolved between flight deck and ground monitors, for example in TBO, and in RNAV/RNP approach and departure operations

While human factors research in the important area of self-separation is still in its challenging early stages, all projects are on a firm track. Understanding the impact of new technologies on human performance and the need to develop error management strategies and associated training is on schedule. Efforts to produce detailed research plans for the ADS-B enabled applications mentioned earlier (OTP, IM, CSPO) are also on schedule. Researchers will continue to execute plans to produce human factors technical data that will allow the FAA to implement the NextGen OIs, enabling reduced and delegated self-separation applications. (NextGen Self-Separation Human Factors)



SITUATIONAL AWARENESS

Common, accurate,
and real-time information
of aerospace operations, events,
crises, obstacles, and weather

LOW COST GROUND SURVEILLANCE SYSTEM

In 2010 the FAA continued test and evaluation of the prototype Low Cost Ground Surveillance system at Spokane International Airport. Displays were installed in the Air Traffic Control Tower and preliminary user evaluation was completed. Pilot systems were also installed at Manchester-Boston Regional Airport, and San Jose International Airport, and are being prepared for technical and user evaluation in FY 2011. Two additional pilot sites will be installed at Long Beach and Reno in FY 2011. (Airport Technology Research - Safety)



TECHNICAL OPERATIONS (TO) HUMAN SYSTEM INTEGRATION (HSI) ROADMAP DEVELOPMENT & HUMAN FACTORS ENGINEERING R&D PLAN

As with all NAS EA roadmaps, updates to the TO HSI roadmap are made on an annual basis in response to revisions to internal organizational planning goals, objectives and timelines as well as changes in linked external projects/systems. The human factors research necessary to successfully implement the TO HSI roadmap is defined in a companion Human Factors Engineering Research and Development Plan. This plan is reconciled with the HSI Roadmap following acceptance of inputs to the HSI TO Roadmap.

In FY 2010, HSI inputs were developed from: (1) review of other NAS EA infrastructure roadmaps, (2) consultation with select TO management and their respective team leads, (3) special conferences held with the TO Human Factors Standardization Team; (4) Advanced Technical Operations Systems and Individual and Team Performance Technical Community Requirements Groups; (5) recommendations from TO directors and (6) review of operation policy documentation. Candidate projects were identified and narratives developed (including anticipated activities, products and preliminary cost estimates) in response to defined human performance issues, identified limitations in current/future workforce environment, and/or changes to TO roles/responsibilities (policy). The projects were then reviewed and either approved for further development and inclusion in the TO integrated work environment (IWE) work package or were re-defined, rescoped, or rejected (and included in the Human Factors Engineering (HFE) R&D Plan).

The 2010 edition of the TO HSI Roadmap included clarification and expansion of the actors involved in the TO enterprise and definition of the major phases of the human factors engineering developments necessary to support the changing workforce and work environment through the NextGen mid- and far-terms. An additional six work packages were identified over the previous edition and integrated into the 2010 TO HSI Roadmap and 2010 HFE R&D Plan. These revisions were subsequently reflected in the TO IWE planning. Additionally, HFE research activities outside the NextGen portfolio (e.g., core projects) were assessed and “research needs” examined and coordinated. (Air Traffic Control/ Technical Operations Human Factors)



MEASUREMENT OF BASELINE CONTROLLER FATIGUE STUDY

The role of fatigue in ATC operational errors has long been of concern to the FAA. Runway incursions have been associated with controller fatigue, especially when the controllers were working quick turnaround shifts with nine hours or less between shifts. The FAA plans to reduce the potential for controller fatigue and error by: (1) revising work-scheduling policies to assure sufficient restorative sleep, (2) modifying shift rotations to minimize disrupted sleep and accumulation of sleep debt, and (3) implementing other fatigue management strategies. Exactly what those changes should be, however, is not clear. Individual differences in vulnerability to sleep-related fatigue and differences between facilities in traffic volume, staffing levels, or training demands may influence both sleep needs and performance capability.

In 2010, under the sponsorship of the FAA’s Quality Assurance and Safety Group and in collaboration with the joint FAA/NATCA Article 55 Working Group on Controller Fatigue, researchers initiated a study to determine the present state of controller alertness and fatigue. It was designed to build on an earlier study that identified work schedules that were especially disruptive of normal sleep and effective cognitive functioning. Because of the many changes that have occurred in the past decade, e.g., changes in automation, traffic levels, workforce demographics, and security practices, the FAA determined that the new study of controller fatigue, sleep, and alertness was needed as a baseline for evaluating the impact of any work schedule policy changes or

other fatigue mitigation strategies. The study goal was to determine contributions of work schedules, other workplace factors, and non-work personal factors to the quantity and quality of restorative sleep, subjective fatigue, and measured alertness.

Twenty-seven facilities were involved in the study, with 208 active controllers providing over 3,200 responses. Objective measures including actigraphy, psychomotor vigilance tests, and sleep/work logs were collected over 14 days. Two types of data were collected – a web-based survey and objective measures of fatigue and alertness. The survey, available to all US ATC personnel, included subjective ratings of fatigue, work schedules, workplace factors such as traffic levels, workload, management policies, safety culture, and non-work personal factors such as napping, family demands, health, and financial worry. Objective fatigue and alertness data were collected in the field from a smaller sample of active controllers working in Air Route Traffic Control Centers, TRACONs, and Air Traffic Control Towers. Together, the two sets of data will answer questions concerning the impact of schedules on sleep quantity and quality, perceived fatigue, and measured alertness. Modeling will allow researchers to determine whether these effects hold across the board, or vary with size and type of facility, level of traffic, staffing, age, level of controller experience, or personal fatigue mitigation strategies. We expect that FAA policies and measures backed by field and survey data will increase both their appropriateness and the likelihood of acceptance by the controller workforce. (Air Traffic Control/Technical Operations Human Factors)

CONTROLLER TRAINING: EVALUATION OF THE TOWER SIMULATION SYSTEM



In 2006, researchers at NASA Ames completed a preliminary study of tower simulator effectiveness for the FAA at three tower facilities. The project evaluated the potential of a specific type of tower simulator system (TSS) for reducing the time required for a controller trainee to check out (or successfully complete training) in the tower cab. The results showed that the simulator had the potential for shortening training times by permitting trainees to

obtain more instruction and practice than would normally be available during standard on-the-job-training in the tower cab. The FAA used this study and other information to build a case for installing additional tower simulators.

For the 2010 follow-up study, NASA developed an online survey to collect subjective data from instructors, controllers, and trainees at 19 TSS sites regarding usability, performance, and effectiveness of the TSS. A questionnaire was also employed to evaluate TSS operational benefits such as initial performance in on-the-job training in the tower cab. They also worked with the FAA representatives to identify other data collected during training that could be used to determine the effectiveness of the TSS.

Based on the approach, materials, and procedures developed and used during this study, the research team also created guidelines for conducting simulator evaluations. These apply to specific reactions-level assessments and general simulator evaluations. The resulting technical report discusses and illustrates various approaches for determining the outcomes of using simulation in a training environment. (Air Traffic Control/Technical Operations Human Factors)

EQUIVALENT VISUAL OPERATIONS FOR NEXTGEN

The safe and efficient flow of traffic in the NAS today is heavily dependent on visual operations. When pilots or controllers acquire traffic visually and provide visual separation for the operations, the throughput of the airport is high. Conversely, when visual operations cannot be supported, operations in the NAS degrade enormously, resulting in significant delays throughout the system.

In FY 2010, CAASD researchers completed an EVO research project that involved developing conceptual procedures that rely on integration of several existing and emerging technologies to achieve the equivalent of visual operations during poor weather conditions. These technologies include ADS-B, CDTI, RNAV, RNP, wake vortex transport prognosis, EVS, and SVS. Most of the conceptual procedures developed rely on CDTI Enabled Delegated Separation (CEDS), where the separation responsibility is delegated to pilots, requires flight crews to use an appropriate CDTI, and mimics the manner in which separation is delegated to pilots in visual conditions today.

This research has identified a number of operations that could use CEDS and other combinations of these technologies to achieve EVO. These operations include single and parallel arrival and departure operations into and out of airports, as well as more efficient airspace operations through such capabilities as closer spaced parallel routes and cockpit-based separations for transitions into and out of en route airspace. A number of these conceptual procedures have been evaluated for pilot and controller acceptance in CAASD's laboratory with highly favorable results, showing them to be feasible for flight crews and ATC, and demonstrating their potential for significant capacity benefits. It is expected that with further work, these conceptual procedures could be authorized, evaluated operationally, and deployed for operational use. Several major airlines see these procedures as "low hanging fruit" for ADS-B applications and are planning on implementing these capabilities in their ADS-B demonstration programs that they are executing jointly with the FAA. (CAASD)

TRAJECTORY BASED OPERATIONS (TBO) IN SEVERE WEATHER

In the 0-20 minute tactical en route timeframe, aircraft intent information is limited when operating in the vicinity of severe weather. Weather avoidance is negotiated between the pilot and controller verbally, and weather avoidance clearances are usually issued as open-clearance vectors or occasionally altitude changes. The vectors are often at the pilot's discretion and the point at which the pilot will return to the original route is sometimes unknown by ATC. This leads to uncertainty and difficulty in maintaining intent for TBO. In TBO, the automation expects a closed-clearance for the purposes of problem detection and resolution. Without a closed-clearance, weather problems in this timeframe must be handled more tactically, relying on procedures similar to those in use today.

In FY 2010, CAASD researchers investigated more accurate and stable trajectories for problem prediction, resolution, and metering functions, leading to improved ability to maintain TBO in en route operations in the vicinity of severe weather.

Previously, CAASD researchers evaluated the use of National Convective Weather Forecast, Corridor Integrated Weather System, and Weather Avoidance Field products for en route weather detection and resolution. In addition, they conducted research into search methods for generating resolutions for solving deterministic weather problems. The current research includes an investigation of graph/routing algorithms to solve en route tactical weather problems using gridded probabilistic weather products. (Deterministic weather products are defined as being in only one of two possible states -- weather that can be flown through, and weather that must be avoided. Probabilistic weather products are defined as having varying degrees of probability of occurrence or varying degrees of probability that the area will be avoided.)

CAASD's en route research prototype, Java En Route Development Initiative (JEDI), as well as rapid prototyping tools, were leveraged for this research. Using established functional performance analysis methods, the most appropriate algorithm was selected for further analysis based on factors such as path cost, successful resolutions, and computation time. CAASD in-house operational experts were also consulted in the operational acceptability of the resolutions. A modified Dijkstra algorithm with a smoothed final path, to reduce the number of turns and improve operational acceptability, was selected for implementation and further lab evaluation using the JEDI prototype. (CAASD)

SYSTEM KNOWLEDGE

A thorough understanding
of how the aerospace system
operates, the impact of change
on system performance
and risk, and how
the system impacts the nation

LASER SAFETY RESEARCH—EVALUATING RISKS ASSOCIATED WITH UNDESIRE LASER COCKPIT ILLUMINATION

HITL evaluations were completed for the performance effects of undesired laser cockpit illuminations. In support of the FAA's goal to characterize the risks associated with undesired cockpit laser illumination, the FAA and the US Air Force Research Laboratory investigated the effects of single-source green (532 nm) laser glare, which is encountered in the commonplace laser illuminations of aircraft, on pilot performance with and without Laser Eye Protection during terminal area operations. Three models of spectacles and one laser glare shield were evaluated. Ten qualified subject pilots operated the FAA's Boeing 737-800 full flight simulator equipped with a high fidelity laser delivery system to collect performance data. The analysis of subject response and performance effects due to various eye protection modes will be reported in 2011. (Systems Safety Management)

FLIGHT CREW INTERVENTION CREDIT

The goal of this research effort was to develop a method that would allow certification credit for good human factors design practice in certification regulation. The method consisted of a scoring algorithm that combines key flight deck design characteristics into an overall level of certification credit for flight crew intervention in response to a system failure. Aircraft manufacturers applied the method to a selection of system failure cases. Based on the input from the manufacturers and further discussion with the FAA and the European Aviation Safety Agency, application areas of the method were evaluated. This showed that the method can support the design and development within a manufacturer to encourage good human factors design practice.

The manufacturers considered the application of the method in the design and definition phase as beneficial since it provides a structured guidance tool to support the analysis and discussion on human factors aspects of the flight deck design and found the method to be easy to use and that effort to apply the method is reasonable. Seven options for implementation of this method in the design and certification process were identified and the evaluation provided recommendations for improving the method. Each option sets particular requirements for further research and development activities. (Systems Safety Management)

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PUBLIC ACCESS TO WORLD-WIDE TRANSPORT AIRCRAFT ACCIDENT DATABASE

The FAA Fire Safety Team in partnership with Transport Canada Aviation and the Civil Aviation Authority of the United Kingdom funded an effort to convert the CSRTG's stand-alone accident database to an internet database, accessible to the public. The accident database was originally developed on behalf of airworthiness authorities participating in the CSRTG.

The screenshot shows the 'Advanced Search' page of the CSRTG Aircraft Accident Database. The page has a dark header with the title 'CSRTG Aircraft Accident Database'. On the left, there is a sidebar with links: SEARCH/DATABASE, DATABASE STATUS, ABOUT / CONTACT, INTRODUCTION, GLOSSARY, DISCLAIMER, and LOGIN. Below these links are logos for Transport Canada, the Federal Aviation Administration (FAA), the Civil Aviation Authority (CAA), and RGWCHERRY. The main content area is titled 'Advanced Search' and contains a warning: 'Warning to Internet Explorer 4 users. The reset button must be used to delete search criteria prior to performing a new search.' Below the warning are 'Back', 'Search', and 'Reset' buttons. The search criteria are organized into a table with two columns: a list of search fields on the left and input fields on the right. The fields include REFERENCE, AIRCRAFT TYPE, WEIGHT CATEGORY, REGISTRATION, YEAR RANGE, LOCATION, COUNTRY, OPERATOR, OPERATION, FIRE RELATED, BOMBING RELATED, SWAMP RELATED, PHASE OF FLIGHT, AIRCRAFT DAMAGE, EVACUATION, NUMBER OF ENGINES, ENGINE CONFIGURATION, ENGINE TYPE, WING CONFIGURATION, NUMBER OF ACES, PASSENGER SEATS PER ROW, OCCUPANT INJURIES, WEATHER CONDITIONS, EXITS, RESIST MEANS, TEXT, and KEYWORD. Each input field has a 'Please Select' or 'contains' prompt. At the bottom of the search area are 'Search' and 'Reset' buttons. A footer at the very bottom reads: '© 2002 CSRTG All Rights Reserved | Privacy Policy | Website Designed and Maintained by Golden Webhost'.

All data was derived from reliable sources, primarily from accident investigating authorities. The database contains accidents involving fixed-wing civil registered transport passenger aircraft (with 19 or more passenger seats) and cargo aircraft; all certificated to Part 25 requirements or equivalent. It includes textual and numerical data, as well as photographs and diagrams. The database contains accidents from 1967 onward and is periodically reviewed and revised. The database contains over 3900 accidents and will be continually updated. The database can be accessed on the web at <http://www.rgwcherry-adb.co.uk/>. (Fire Research and Safety)

ACRONYMS AND ABBREVIATIONS

2D	Two-Dimensional	EMS	Environmental Management Systems
4D	4-Dimensional		
ACFPP	Aircraft Catastrophic Failure Prevention Program	EPA	Environmental Protection Agency
ACRP	Airport Cooperative Research Program	EVO	Equivalent Visual Operations
ADDS	Aviation Digital Data Service	EVS	Enhanced Vision System
ADS-B	Automatic Dependent Surveillance-Broadcast	FAA	Federal Aviation Administration
AEDT	Aviation Environmental Design Tool	FAR	Federal Aviation Regulation
AEE	FAA Office of Environment and Energy	FASTER	Full-Scale Aircraft Structural Test Evaluation and Research
ANSP	Air Navigation Service Providers	FCG	Fatigue Crack Growth
APM	Automated People Mover	FIP	Forecast Icing Products
ARTCC	Air Route Traffic Control Centers	FMS	Flight Management System
ASPIRE	Asia & Pacific Initiative to Reduce Emissions	FY	Fiscal Year
ASTM	American Society for Testing and Materials	GC/MS	Gas Chromatography/Mass Spectrometry
ATC	Air Traffic Control	GE	General Electric
ATM	Air Traffic Management	GHG	Greenhouse Gas
AVS	Aviation Safety	GTG	Graphical Turbulence Guidance
CAAFTI	Commercial Aviation Alternative Fuels Initiative	GUS	General Unknown Screening
CAASD	Center for Advanced Aviation System Development	HCF	High Cycle Fatigue
CAEP	Committee on Aviation Environmental Protection	HDDAM	High Density Area Departure/Arrival Management
CAMI	Civil Aerospace Medical Institute	HFE	Human Factors Engineering
CDTI	Cockpit Display of Traffic Information	HITLS	Human-in-the-Loop Simulations
CEDS	CDTI Enabled Delegated Separation	HRP	Heat Release Parameter
CHF	Critical Heat Flux	HSI	Human System Integration
CIP	Current Icing Products	IDEA Lab	Integration Demonstration and Experimentation for Aeronautics Laboratory
CO ₂	Carbon Dioxide	IM	Interval Management
COE	Center of Excellence	IWE	Integrated Work Environment
CONOPS	Concept of Operations	JEDI	Java Enabled Route Deviation Initiative
CSPO	Closely Spaced Parallel Operations	JPDO	Joint Planning and Office
CSPR	Closely Spaced Parallel Runways	LC/DAD	Liquid Chromatography Array Detection
CSRTG	Cabin Safety Research Technical Group	LIDAR	Light Detection and Ranging
CWT	Center Wing Fuel Tank	LOSA	Line Operations Safety Analysis
DARWIN®	Design Assessment of Reliability With INSpection	LTO	Landing and Takeoff Operations
DNL	Day-Night Average Sound Level	MIT	Massachusetts Institute of Technology
DOE	Department of Energy	MMPDS	Metallic Materials Properties Development Standardization
DOT	US Department of Transportation	MPRWG	Medical and Performance Working Group
DRG	Design Review Group	NARP	National Aviation Federation
EA	Enterprise Architecture	NAS	National Aerospace and Space Administration
EFB	Electronic Flight Bag	NASA	National Aeronautics and Space Administration
		NextGen	Next Generation Air Transportation System

NOAA	National Oceanic and Atmospheric Administration	RTA	Required Time of Arrival
NOx	Nitrogen Oxide	RUC	Rapid Update Cycle
NTSB	National Transportation Safety Board	SAE	Society of Automotive Engineers, Inc.
OI	Operational Improvement	SAO2	Hemoglobin Oxygen Saturation
OTP	Oceanic in-Trail Procedures	STBO	Surface Trajectory-Based Operations
PARTNER	Partnership for AiR	SVS	Synthetic Vision System
	Transportation Noise and Emissions Reduction	TBO	Trajectory-Based Operations
PM	Particulate Matter	TCAS	Traffic Alert and Collision Avoidance System
PRA	Probabilistic Risk Assessment	THC	Total Hydrocarbon
PROTE	Reduced-Oxygen Enclosure	TMA	Traffic Management Advisor
R&D	Research & Development	TO	Technical Operations
RMS	Risk Management System	TRACON	Terminal Radar Approach Control
RNAV	Area Navigation	TRP	Thermal Response Parameter
RNP	Required Navigation Performance	TSO	Technical Standard Order
RPI	Relative Position Indicator	TSS	Tower Simulator System
RR	Rapid Refresh	UV	Ultraviolet
		VBB	Vertical Bunsen Burner
		WRF	Weather Research and Forecasting

The NARP, related appendices, and the *R&D Annual Review* may be found online at:

www.faa.gov/go/narp

